For Editorial Contents see page 431

PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION.

Engineering Library

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY CHAS. COOPER AND J. FOSTER PETREE.

TEMPORARY OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 18 & 20, COMPTON ROAD, HAYES, MIDDLESEX.

VOL. 151—No. 3933. LONDON: FRIDAY, MAY 30, 1941. Registered at the General Post Office as a Newspaper. PRICE 1s. BY FOREIGN POST 1s. 2d.

JUN 21 1941

Air Receivers Buoys, Road Wagons Tanks. TANKS Hoppers, Chimneys, Ducting.
EVERYTHING FROM MILD STEEL PLATE.
JOHN BELLAMY
EAST 1802 LIMITED. Est. 1860
MILLWALL E.14 1216

J. & E. HALL
REFRIGERATION
FOR LAND & MARINE PURPOSES
LIFTS AND ESCALATORS
J. & E. HALL, LTD., ENGINEERS, DARTFORD, KENT.
Telephone: Dartford 3456.
London Office: 10, ST. SWITHIN'S LANE, E.C.4.
Telephone: MANSION HOUSE 9811.
1263

PATTERNS
B. LEVY & CO. WOOD & METAL. Osbert St., S.W.1 Vic. 1073

METAL SLITTING SAWS
GROUND FLAT STOCK
WILLIAM WARD & SON (SHEFFIELD) LTD. CENTENARY WORKS, WOODSEATS ROAD, SHEFFIELD. 712

SECTIONAL PRESSED STEEL TANKS
also
RIVETED and WELDED PLATEWORK STORAGE TANKS, BUOYS, CHIMNEYS, BUNKERS, HOPPERS, Etc.
BROWN, LENOX & CO.
(LONDON), LIMITED.
Contractors to the Admiralty since 1808.
MILLWALL LONDON, E.14.
Telephone: East 0700/1. 1342

GLOVES
For Steelworkers, Stokers, Miners, Welders. Women's munition gloves in Chamois or Leather,
MACPHAIL & KAY Ltd.,
WOODLEY, Nr. STOCKPORT.
See last week's ¼ page.

FOR HIGH CLASS
PATTERNS & MODELS
Phone: EUSton 3176 (4 lines).
GEORGE WAILES & CO. LTD.
382-8, EUSTON RD., LONDON, N.W.1.
Specialists since 1855 669

LOCOMOTIVES
STEAM OR DIESEL
HUDSWELL CLARKE & Co. LTD.
RAILWAY FOUNDRY, LEEDS.
London Office: 46, Victoria St., S.W.1.
Telephone: Victoria 1133 8559

SPENCER - BONECOURT
Patent Waste Heat Boilers
32, Farringdon Street, London, E.C.4. 1332

YARROW
& CO., LTD.
GLASGOW
SHIPBUILDERS
MARINE ENGINEERS 1353
LAND AND MARINE BOILER MAKERS

PETER BROTHERHOOD
PETERBOROUGH LTD.
STEAM ENGINES AND TURBINES
GAS AND OIL ENGINES,
AIR COMPRESSORS,
REFRIGERATING PLANT.
See Advertisement, Page 31. 6938

SPRINGS
FOR ALL PURPOSES
1137
WILLFORD & CO. LTD.,
PARK HOUSE WORKS, SHEFFIELD, 9

DREDGERS
OF ALL TYPES
FERGUSON BROS. (Port-Glasgow), LTD.
PORT-GLASGOW. 1078

FORGINGS.
WALTER SOMERS, LTD.,
HALESOWEN 7116

WAGONS
HURST, NELSON & CO., LTD.,
MOTHERWELL. 3382

VISCO
AIR FILTERS
DUST COLLECTORS
COOLING TOWERS 1128
THE VISCO ENGINEERING CO., LTD.
Stafford Road, Croydon. Phone: Croydon 4181/5

FRASER
WATER-TUBE
BOILERS
'PHONE: FRASER & FRASER LTD. 'GRAMS
ADVANCE 3266 Bromley-by-Bow, London, E.3. PRESS, BOCHURCH, LONDON.

WATER SOFTENING
PATERSON ENGINEERING CO., LTD
83, KINGSWAY, LONDON 780

SPECIAL MACHINES
MADE TO ORDER
Parts and repairs
Erection of Plant
Millwrights work 1461
THOMAS HUNT & SONS
Westbridge Road. BATTERSEA, S.W.11.

COUPLINGS & DETUNERS
FOR ALL PURPOSES
THE WELLMAN BIBBY CO., LTD.
VICTORIA STATION HOUSE, VICTORIA STREET
LONDON, S.W.1.
Telephone: Victoria 7762.

HYDROJET
BABCOCK & WILCOX

RAPIER
Builders of Europe's Largest
EXCAVATORS
RANSOMES & RAPIER, LTD
IPSWICH 1553 ENGLAND

CRADLEY BOILERS
CRADLEY BOILER CO., LTD., 1306
CRADLEY HEATH, STAFFS.

MUREX
Electrodes
MUREX WELDING PROCESSES LTD.,
WALTHAM CROSS, HERTS.
Telephone: Waltham Cross 3636.

MACROME
LIMITED
NOW
GUARANTEE
100%
AVERAGE LIFE INCREASE
For High Speed and Carbon Steel Cutting Tools after Macrome Treatment.
Z.Dept., ALCESTER, WARWICKSHIRE.
Tel.: ALCESTER 175.

CRANES
GEORGE RUSSELL & CO., LTD.,
Motherwell. 1317

PULLEYS
BARRY, HENRY & COOK, LTD.

THOS. W. WARD LIMITED
4-wheel 9 in. by 15 in. STEAM LOCOMOTIVE, copper firebox; new steel tubes 1941; 160 lb. working pressure.
5-ton "STOTHERT & PITT" LOCO. STEAM CRANE, 25 ft. jib; 8 ft. gauge.
10-ton "WILSON" ELECTRIC TRAVELLING DERRICK CRANE, 70 ft. jib; with travelling bogies; 250 volts D.C.
SEMI-PORTABLE LOCO. BOILER, 8 ft. 2 in. long overall; barrel 2 ft. diameter; w.p. 150 lb.
VERTICAL CROSS-TUBE BOILER, 7 ft. 6 in. by 3 ft.; w.p. 80 lb.
BOILER DRUMS, each about 26 ft. long by 4 ft. 6 in. diameter, suitable for use as receivers and re-insurable at 200 lb. per sq. in. pressure.
Write for "Albion" Catalogue.
ALBION WORKS, SHEFFIELD.
'Grams, Forward, Sheffield; 'Phone 26311 (15 lines).

Alfred Herbert Ltd., Coventry
PAY BEST PRICES for SECONDHAND MACHINE TOOLS in good condition, by first-class makers.—Write, wire, or phone, and our representative will call. 'Phone 88781 Coventry. Telegrams LATHE, Coventry. W 305

Research Engineers, Ltd.,
Northampton Grove, Canonbury, London, N.1. DESIGN and CONSTRUCTION of MECHANICAL and ELECTRICAL MACHINERY and APPARATUS.
EXPERIMENTAL WORK OF ANY DESCRIPTION. 1616

ASH & DUST
LTD., 34, FARRINGDON

On Active Service
COOPER
SPLIT
ROLLER BEARINGS
KING'S LYNN 1158 NORFOLK

WATER PURIFICATION PLANT
OF EVERY DESCRIPTION
JOHN THOMPSON
(KENNICOTT WATER SOFTENERS) LTD.,
WOLVERHAMPTON 1203

SYNTHETIC
MILLING CUTTER
SPACERS
OF SPECIAL OIL-PROOF SYNTHETIC RESIN
In thicknesses from ·001" to ·020" (including ·0015"). Each thickness in own distinctive colour for quick identification.
AUTO AERO Ltd.,
44 Packington Rd., Acton, London, W.3

WATER TURBINES
GILBERT GILKES & GORDON LTD.,
KENDAL, ENGLAND. 1252

TAYLOR AND CHALLEN
POWER PRESSES
TAYLOR AND CHALLEN LIMITED 1172
DERWENT WORKS, BIRMINGHAM, 19

SAMUEL PLATT
LIMITED
King's Hill Foundry, Wednesbury, Staffs.
DRAWBENCHES
FOR
AIRCRAFT WORK 689

ALLDAYS & ONIONS
1132 BIRMINGHAM. LTD.
SMITHY PLANT

"The machine with a BRAIN"
SCIAKY
SPOT WELDERS
SLOUGH —— 22342

LIGHTALLOYS LTD.
FIRST QUALITY
ALUMINIUM CASTINGS
ALPAX WORKS, St. Leonard's Road, Willesden Junction, London, N.W.10. Telephone: Willesden 3460-1-2. Telegrams: "Lightalloys-Phone-London."

AIRPEL PATENT PUMPS
AIR PORT EQUIPMENT LTD.
AIRPEL WORKS. WEMBLEY. MIDDX.

SLUICING 1334
STREET, LONDON, E.C.4

MAY 30, 1941 — ENGINEERING — VOL. 151, PAGES 421–440

"Come in, Doctor" . . .

Powers Samas machine room in underground air raid shelter at Macleans Ltd., Gt. West Road, Brentford. Walls and ceiling lined with Acousti-Celotex.

Doctors know the delicate mechanism of the human ear, the reactions of the nervous system . . . . they know that NOISE STRIKES AT HEALTH — the mainspring of efficiency . . . . In factories, the insidious mischief of excessive noise becomes apparent in mistakes and absences. There is need in many factories and business premises for ACOUSTI-CELOTEX to effect the cure . . . . possibly in yours? Send for an acoustical expert from Celotex or give details of your problem to: **Celotex Limited, Stonebridge Park, N.W.10, or to your distributor.**

ACOUSTI-CELOTEX
MADE IN ENGLAND

REGIONAL DISTRIBUTORS

HORACE W. CULLUM & COMPANY LIMITED, CONNAUGHT GARDENS, MUSWELL HILL, N.10 — SOUTH OF CHESHIRE AND YORKSHIRE • WILLIAM BEARDMORE & COMPANY, LIMITED, PARKHEAD STEEL WORKS, GLASGOW — NORTH OF THE CHESHIRE SOUTHERN BORDER, EXCLUDING YORKSHIRE • J. H. BEAN & COMPANY, LIMITED, 22, BASINGHALL STREET, LEEDS, 1 — COUNTY OF YORKSHIRE

ACX/E

THE TESTING OF DUST-EXTRACTION PLANT.

THE limitation of smoke and dust emission from factory chimneys has figured for so long among the imperfectly solved problems of industry that public health authorities and smoke abatement societies may be pardoned, perhaps, for suspecting that engineers have attacked the problem rather half-heartedly, and then only when compelled to do so by legal enactment or the force of public opinion. It is admittedly rather difficult to raise much interest in flue-gases, once they are passing up the chimney with as much as possible of their useful qualities extracted, and, while the engineer does not dispute that black smoke is undesirable—especially since he has realised that it indicates inefficient combustion, he gains little satisfaction from the prospect of installing and maintaining expensive plant to recover dust and fine ash that he would only too gladly give away. It can be urged on behalf of the engineer, moreover, that air pollution surveys have established that the aggregate of small users of solid fuel for domestic purposes are more responsible for atmospheric corrosion and the reduction of beneficial solar radiation than are the relatively few large consumers. These considerations, however, do not relieve the owners of central power stations or large industrial plants from their obligation to minimise what may be, locally, a serious nuisance. When the owner is a public authority, of course, such responsibility is accepted, and it is probably true to say that the very considerable improvements of dust-extraction appliances and practice that have taken place in this country during the past ten years are closely bound up with concurrent developments in the large-scale generation of electric power. In this connection, Sir Leonard Pearce* has recently made the point that it may be more economical to locate a station near the centre of its electrical load, despite the cost thereby involved of installing and operating flue-gas cleansing plant, than to face the alternative of many miles of underground transmission.

Fig.1.

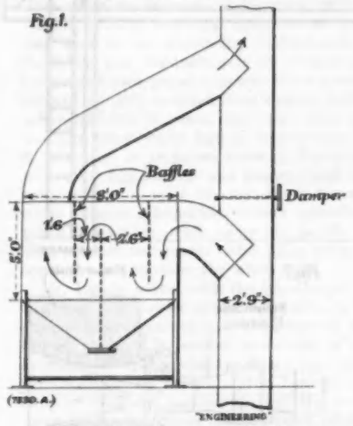


Fig.2.

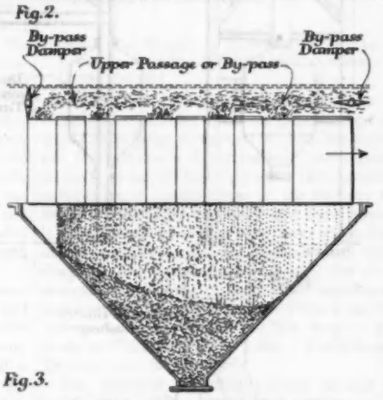
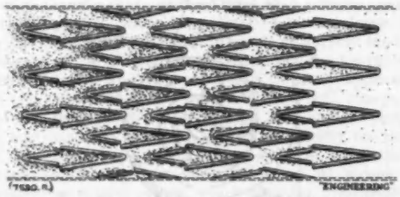


Fig.3.



Equally as important as the erection of large power stations in densely populated surroundings is the increasing use of pulverised-fuel furnaces, which, not without evidence, are commonly held to distribute higher proportions of chimney dust than are produced by mechanical stokers. Thus, Mayer† stated that the concentration of dust particles does not usually exceed one grain per cubic foot with stoker firing, unless the fuel has an exceptionally high ash content; whereas, with pulverised-fuel firing, concentrations of 4 grains per cubic foot often occur, while 15 grains per cubic foot may be achieved during soot blowing. More recent figures, quoted from a survey of American practice by Barkley,‡ indicate that the proportions of the ash originally in the coal which find their way into the chimney range from 5 to 30 per cent. in the case of underfeed stokers, from 20 to 40 per cent. with spreader stokers, and from 50 to 85 per cent. for pulverised-fuel installations. Accompanying this ash, states Barkley, there may be combustible material varying from 10 per cent. to as much as 85 per cent. of the fly ash.

The general recognition of the circumstances in which dust extraction is a social necessity has tended to be anticipated by the design of plant for that purpose, and we in this country may feel some belated satisfaction at being pioneers in both these respects. Mayer, in his paper of 1932, displayed a sound appreciation of the essential requirements of effective equipment, and while admitting that no single type of apparatus available at that date was capable of fulfilling them, was able to refer, from current practice, to practically all the types of extraction procedure that are in service to-day, ranging from coal cleaning to electrostatic precipitation. He emphasised, moreover, what is still an important point ten years later; namely, that the variation of efficiency with boiler load was a defect of almost every individual type of extractor, and that the most satisfactory practical solution was often to be attained by a combination of two extraction principles, each more efficient than the other over half the working range of the boiler.

This principle was not markedly emphasised by Barkley in his report mentioned above, although it is exemplified in a few of the types of dust-separating apparatus that he described. He prefaced his remarks on this subject by stating that the dust from underfeed or spreader stokers is easier to separate from the flue gases than that from pulverised-fuel equipment. For either form of furnace, however, any of the methods of extracting dust appear to be indiscriminately used, and even a brief reference to the various types will bring out points of interest. One of the simplest consists of steam jets mounted at some convenient position in the flue and directed so as to impart a swirling downward motion to the products of combustion. In some installations, the steam jets are placed in the upper part of the furnace, into which they inject air by means of suitably-designed nozzles. To a certain extent, the steam tends to unite fine ash into heavier aggregate particles, which thus separate out more readily. It is claimed that an appreciable amount of dust can be kept out of the flues by such means; but no figures appear to be available, and it seems reasonable to suppose that the steam-jet separator is one of the devices that can most advantageously be used in combination with some form of mechanical apparatus.

The same remark seems to apply, also, to the numerous variations of the sedimentation principle, by which dust settlement is promoted by reducing the upward velocity of the flue gases. This may be accomplished, as illustrated in Fig. 1, herewith, by enlarging the cross-sectional area of a vertical flue; or by making part of the flue horizontal, or by baffling the gases so that part of their course is vertically downwards. With any of these arrangements there may be combined various forms of vane baffles or dampers, intended to trap the heavier dust particles. Provision is made in some installations for such particles, which probably include much of the incompletely burned fuel, to be collected in hoppers and returned to the furnace for refiring, either periodically by manual operation or continuously by the aid of a steam-jet injector. A valuable feature of movable baffles is that they can be adjusted to suit the working rate of the boiler and their most effective performance maintained in accordance with predetermined trial results. Among many interesting variants of the baffling principle may be mentioned the use, as in Figs. 2 and 3, on this page, of a succession of Venturi passages formed by arranging lozenge-shaped, hollow baffles vertically in a horizontal duct. Narrow slots near the Venturi throats trap a proportion of the flue gas in which dust tends to be concentrated near the boundaries of the throats. The trapped ash falls through the hollow baffles to a receiving hopper, while the cleaned gas rises to rejoin the main line of flow in a return duct.

In all the foregoing methods of dust extraction, the force available for separating the dust from the gas in which it is being conveyed is seldom more, and never much more, than the earth's gravitational attraction upon the individual particles. Opposing this attraction is the aerodynamic resistance to the motion of the particles through the flue gas, so that the net force tending to cause precipitation may be so trifling as to be ineffective, or may even remain negative in the case of the finer or less dense material. The cyclone and power-operated centrifugal types of dust separator are designed to overcome this difficulty by imparting rapid rotation to the dust-laden gases. The solid particles are thus subjected to what is, in effect, a greatly enhanced gravitational field with no commensurate increase in aerodynamic resistance. The precipitation time of all particles is thereby reduced, and the minimum size of particle that can be separated within a practicable time limit is much smaller than with simple unit-gravitational separation. The maintenance of high gas velocities in cyclone separators is very desirable, because the centrifugal force causing separation is proportional to the square of the velocity. Cyclones, accordingly, are generally designed for high gas velocities and relatively small diameters, and their efficiency falls off noticeably if the gas velocity is reduced as the result, for example, of reduction in the rate of boiler working. To overcome this difficulty, and thus to take care of varying loads, a common expedient is to install a sufficient number of cyclones in parallel to deal with the whole battery of boilers on peak load, and to vary the number in parallel at lower loads so that each cyclone is always working at high efficiency. Barkley illustrates, in his paper (Figs. 4 and 5, page 422), a battery of 14 cyclones arranged in two banks of seven each, discharging the separated dust vertically downwards into a long hopper along which the dust is conveyed by an Archimedean screw into a receiver at one end. An alternative method of maintaining efficiency is to use a movable damper, which throws dust to the outer edge of the cyclone, thus mechanically compensating for the lower centrifugal force. Some makes, embodying this "shave-off" principle, are claimed to have a loss of efficiency of only about 5 per cent. from full load to half load. Among Barkley's examples is a combination of primary concentrator composed of fixed vanes, which "shaves off" about 15 per cent. of the dust-laden gases and delivers them to a secondary cyclone separator. In some designs of induced draught fan, as in Fig. 6, page 422, the blades are shaped to act as centrifugal separators, discharging the dust into chambers let into the outer casing, or delivering a small proportion of the gases, concentrated with dust, to a cyclone for separation, the cleaned gases being returned to the fan.

One important means of lowering the amount of

* *Proc. I. Mech. E.*, vol. 142, page 349 (1939).

† "Review of the Methods of Dust Removal from Power Station Flue Gases," *Proc. Inst. Fuel.* See ENGINEERING, vol. 133, page 532 (1932).

‡ "Reduction of Fly-Ash Emission from Chimneys," by J. F. Barkley, United States Bureau of Mines: *Report of Investigations*, No. 3472. (September, 1939.)

fly ash, to which Barkley refers, is to return it to the furnace for reburning. When this practice is followed, the ash should be returned to a part of the furnace, where the temperature is high or where there is considerable flame. Special burners have been designed for this purpose. They take the form, shown by Fig. 7, herewith, of steam-jet injectors, which induce air along with the ash and mix them in a suitably shaped chamber contained in the thickness of the boiler wall. As an alternative to the steam jet, a small auxiliary forced-draught fan may be used. Continuous operation is possible in either case, control being adjusted to suit the rate of dust accumulation which, is dependent on boiler load.

An important development, possibly originating in the simple forms of steam sprays used in the chimney stack, is the water-spray type of dust separator, of which a notable example, illustrated diagrammatically by Fig. 8, on this page, is in use at the Hell Gate electric power station in New York. Such sprays may be combined with advantage with baffling arrangements in the flues to reverse or retard the velocity of dust-laden gases, or with directional vanes to produce centrifugal motion in the gases. Provision is often made for recirculation of the scrubbing water from which the dust has been precipitated in a settling cone. Continuous dust separation by the wet process gives rise to a good deal of corrosion trouble, since the water acquires sulphuric acid ; but this is not serious if the sprays are employed only intermittently, as during soot blowing, and the contaminated surfaces are thoroughly dried by hot gases in the intervals. An unusual spray installation, cited by Barkley, is designed for use at the top of the stack, where its cooling effect on the effluent gases slightly increases the draught. It is a disadvantage of many water-spray systems that the flue gases become so saturated as to require treatment by a water arrester before passing to the chimney. In wet separators of the film type this defect is avoided, the gases being merely brought into contact with surfaces covered with a thin film of water. This serves to extract the dust without excessive evaporation or carriage of water drops along with the cleaned gases.

At present there seems to be insufficient evidence to state how the efficiency of the wet dust-extraction principle varies according to the size of dust particle. With baffle, centrifugal and cyclone extractors, it appears inevitable that the effectiveness must fall off markedly as the particle size decreases below about 40 microns (0·04 mm.). This is a disadvantage so far as concerns pulverised-fuel furnaces, since the dust they produce is finer, on the average, than that from stokers and presumably, therefore, contains a higher proportion of dust less than 40 microns in size. In this respect it seems likely, though again definite evidence is meagre, that electrostatic precipitators should be particularly valuable. They function by imparting a negative charge to the dust particles, causing them to be attracted to earthed, relatively-positive, electrodes, upon which they are deposited, losing their charge. They may be dislodged by mechanical rapping or vibration into collecting hoppers. They require high-voltage direct-current, occupy more space than other types of extractor, and vary in efficiency with gas velocity, but have the advantages that the dust is collected dry and that they cause little loss of heat and draught.

The minimum size of particle which any form of extraction apparatus can be relied upon to trap is a matter of some moment from the standpoint of smoke and dust abatement. In the absence of extraction plant, the larger particles, less easily carried by the wind, are concentrated within a mile or two of the chimney and are an obvious source of nuisance in built-up residential or office areas. Particles of less than about 20 microns in mean diameter are visible only in the mass, as smoke ; and, since they are widely dispersed from a tall chimney stack, they cause less annoyance than falling dust, though their reduction of ultra-violet sunlight may have a detrimental influence on public health, which is the more serious for being often unsuspected. Hardie,* who makes this point in the course of an analysis of the factors governing equitable legislation regarding dust emission, observes that, since the blackness of the smoke particles aggravates their ill-effects, every effort should be made to foster those combustion conditions which decrease the carbon content of flue dust, in which respect pulverised-fuel firing usually has an advantage over stoker firing. In either case, remarks Hardie, it is the concentration of deposited and suspended particles that matters, rather than the actual concentration in the effluent gases, and it is, therefore, reasonable to impose a lower permissible limit for the dust emitted from low stacks than from high ones.

Among other considerations to which Hardie directs attention is the ash content of the coal mined or normally used in any particular locality. He suggests that, since the efficiency of dust-extraction plants is unaffected by the concentration of dust in the gases passing through them, the higher the ash content of the coal used, the greater must be the quantity of dust emitted for a given coal consumption. It is important to distinguish between the quantity of dust and its concentration in the gases leaving the chimney, as legislation in terms of concentration penalises efficient boiler operation, in which low proportions of excess air and gas-tight flues tend towards high dust concentrations. The distinction hinges on the point of view : on whether the extent of pollution is of primary consequence, in which case the total quantity of dust and such related factors as the total weight of fuel burned or the proportion of rapidly precipitated particles are matters of moment ; or whether interest centres mainly round the performance of dust-extraction apparatus, in which case the average and maximum concentrations of dust in the effluent gases become of major importance. In this connection, Hardie considers that a plant which never exceeds a permissible limit of dust concentration, yet always operates close to that limit, can rightly be regarded as mechanically superior to one which, sometimes exceeding the limit but giving a lower average emission, is preferable from the air pollution point of view.

Evidently, therefore, the ability of apparatus to extract dust, and the characteristics of available designs in relation to rates of boiler working, types of furnace, and discrimination as regards particle size, are among the most important and debatable factors affecting the consideration of allowable limits for dust emission. In emphasising this point, Hardie asserts that, without exceptional operating care, involving continuous sampling and frequent adequate tests by specially trained staff, the day-

TESTING DUST-EXTRACTION PLANT.

Fig. 4.

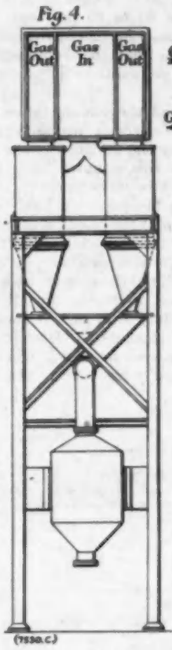


Fig. 5.

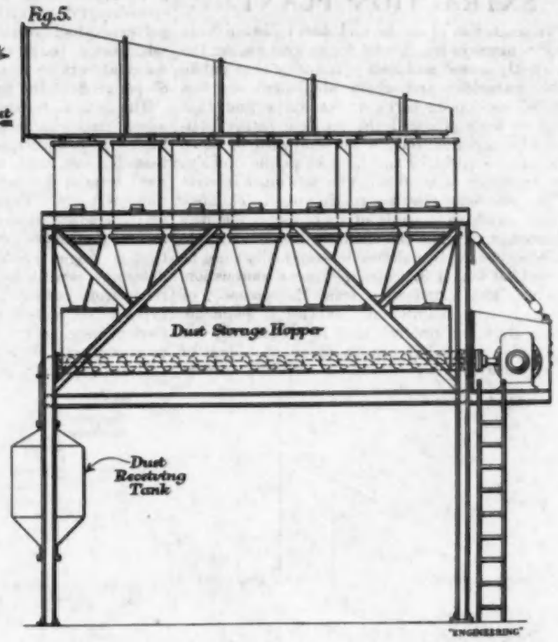


Fig. 6.

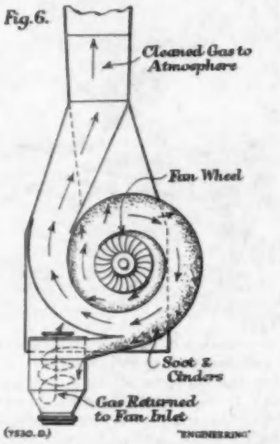


Fig. 7.

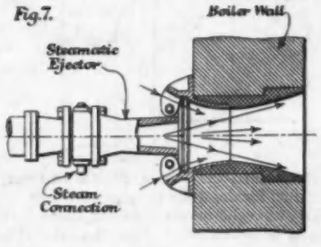
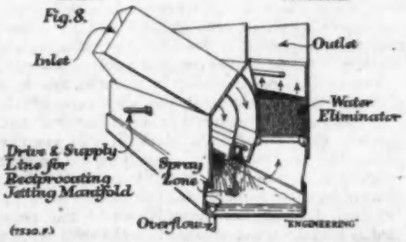


Fig. 8.



* "Defining Equitable Limits of Dust Emission from Stacks," by P. H. Hardie, *Mechanical Engineering*, December, 1939, page 50.

to-day efficiency of dust-extracting plant is likely to be 5 per cent. lower than the efficiency obtained on a full-dress acceptance test. If, to take an example, the normal efficiency is only 85 per cent., whereas the acceptance efficiency of 90 per cent. just covers the permissible dust emission, the actual dust emission becomes 50 per cent. greater than that allowed. Along with the general trend towards the abatement of chimney-dust emission will come the need to formulate equitable limits, to express them numerically and to achieve them with extraction plant of guaranteed performance.

(To be continued.)

LITERATURE.

Works Organisation and Management. By E. J. LARKIN. London: Sir Isaac Pitman and Sons, Limited. [Price 35*s.* net.]

THE effort to increase engineering efficiency and output is daily becoming more intense and with it the need for an increasing understanding of the functions and fundamentals of workshop organisation and management become more pressing. The subject has only received the attention that it merits within the last 20 years, and many older executives in engineering works had no opportunity to study it at college or technical school. Numerous books on works organisation and management have now been written; some are too short to survey the whole subject adequately, others specialise in one particular aspect, while some are merely compiled with scissors and paste. This book attempts, with some success, to cover the whole field.

Mr. Larkin writes with the knowledge of a practical man, who, by lecturing on his subject, has found exactly where instruction is most needed, and shows himself to have a detailed knowledge of the many branches of management. From the choice of a factory site, the layout of the factory, its power supply, heating, ventilation, lighting and equipment he passes to the consideration of jigs, tools, time recording, time study, accidents, shop drawings, estimating, planning, progressing, standardisation, research, purchasing, ordering, inspection, storekeeping and sales. The use of charts is stressed, and personnel training and payment by results receive particular consideration. The present times add point to such conclusions of the author as that "in some cases the establishment of a branch works in another situation may yield a better return than an extension of the original factory," and his preference for reinforced concrete as the constructional material for multi-storey buildings.

Group drive for machine tools is advocated in Chapter IV, but is condemned in Chapter VII; while nearly half of the chapter on machine tools is devoted to illustrated catalogue descriptions of selected tools. A discussion of the uses of these and other machines would have been of greater benefit. The advantages of the distribution of cutting fluids by piping from central tanks to groups of machines might have been pointed out. When dealing with power supply, no mention is made of disadvantage of unusual voltages, which still persist, or of the advantages in a small works of direct current. The chapters on time recording and time study provide good surveys of two different subjects, while the drawing office, estimating, production planning and progressing are fully dealt with; a number of useful forms are set out and the advantages of the use of the Gantt chart are shown. In the chapter on purchasing, good examples of conditions of contract and stores tenders are given.

It is perhaps inevitable that the small factory should be considered last, although, as the author mentions in Chapter X, 32 per cent. of the employees in Great Britain work in factories having a personnel of 100 or under, too small for many of the schemes he suggests to be carried out. It is in the small works that the machine-hour rate method of costing, which is not mentioned, has its widest application.

The author's views on the subject of personnel may be summed up in his observation that "It is frequently necessary to fit the job to the individual rather than the individual to the job"; a principle which might well be applied to inspectors of factories, who should be entrusted with the supervision of factories engaged in a small number of similar trades in a large area, rather than of every factory, of whatever kind, in a small area. The chapter on payment by results instructively compares pure piecework, the Halsey, Halsey-Weir and Rowan systems, but in one respect the author is less than just to the pure piecework system. Not only should it be based on man-hours, but it is psychologically better to give the individual worker a time rather than a price, and correspondingly easier to adjust such times for different grades of workers. The training of apprentices is a subject in which the author has especial interest. He favours entry to the university directly from school, and workshop experience during the long vacation. Many will disagree with him, but the description of the Larkin system of workshop training deserves careful reading. It is a notable feature of the book that so many chapters provoke thought, and, occasionally, disagreement, although based on fundamentals which cannot be challenged.

Pumps. By FRANK A. KRISTAL and F. A. ANNETT. London: McGraw-Hill Publishing Company, Limited. [Price 24*s.* 6*d.*]

AT first sight, it might seem that there is little occasion for another book on pumps, especially one in which so large a proportion of its 385 illustrations are reproductions from makers' catalogues; yet, without going all the way with the authors of this work in their observations on the paucity of books dealing with types of pumps and their applications, it may be conceded that they have compiled a very useful conspectus of the subject and that some chapters are particularly valuable for their consideration of details of design and operation which most writers have inclined to regard as relatively unimportant. Examples are the chapters on "Methods of Priming Pumps" and "Centrifugal Pump Troubles and Remedies."

The chapters on reciprocating pumps and on volute-type, diffuser-type and turbine centrifugal pumps, while based largely on catalogue matter, present it well and bring out effectively the features of the different designs, the reasons for their differences, and the particular fields of application to which they are suited. Deep-well pumps, boiler feed pumps, and sewage and sludge pumps are similarly treated. Of greater novelty are the chapters on propeller pumps—a type which has been attracting increasing attention in recent years; on rotary pumps, which contains brief descriptions of a number of designs of comparatively recent introduction; and on variable-displacement and proportioning pumps. The determination of head, and the various interpretations of the term; economical sizes of pipes for pumping systems; pump characteristics, and other factors involved in practical operation; pump drives; the selection and installation of types appropriate to different duties; and the comparative economies of using old and modern types of nominally equal output, are each the subject of a separate chapter. An appendix contains, in addition to the customary tables and data, some of a less familiar kind, designed to assist in the proportioning of pumping plant for such special uses as drinking-water supply for farm stock, and water services to swimming pools.

It will be gathered from the foregoing summary that this book is one for the potential user of pumps rather than for the designer of the pumps themselves. The authors have ranged widely in their survey, and acknowledged by name, in the preface, the collaboration of no less than 108 manufacturers, all in the United States. In one sense, this wholly Transatlantic exemplification of their points may seem to limit the utility of the book to British readers; but, in fact, this is not the case, although the nature of the utility differs from that which the American reader is likely to find in it. Many earlier books on pumps have been spoiled by too narrow an outlook, and the restriction of illustrative examples to the products of a few firms; this one, however, broadly surveys a considerable industry, and might be studied with advantage by British manufacturers who contemplate extending their overseas trade after the war.

VIS-A-VIS INTERNAL-COMBUSTION ENGINES.

By W. A. TOOKEY, M.INST.C.E.

As far as records go, it would appear that the first internal-combustion engine developed on the vis-à-vis cylinder arrangement dates back to the year 1887, when Mr. Hugh Williams designed for Messrs. J. and E. H. Andrew and Company, Limited, of Reddish, near Stockport, a two-stroke cycle gas engine, two of which were set to work in the following year to drive dynamos for lighting the Lyric Theatre, London, when it was first opened. A photograph of one of these engines is reproduced in Fig. 1, on page 424. Mr. A. R. Bellamy, now of Messrs. Ruston and Hornsby, Limited, Lincoln, referred to this engine during the discussion of Mr. Herbert A. Humphrey's paper on "Power-Gas and Large Gas Engines for Central Stations," presented to the Institution of Mechanical Engineers in 1901.*

Mr. Bellamy has informed the writer that he himself made many of the working drawings of what in those early days was "a big leap in the dark," and that he was present on the opening night of the Lyric Theatre, when the engines were first put into service. Each engine developed 50 indicated horse-power and gave two impulses per revolution—one from each of the cylinders—on a common crankpin. At that date the Otto patent on the four-stroke cycle principle had not yet expired and competitors to the British licensees—Messrs. Crossley Brothers, Limited, of Openshaw—were all producing, with more or less success, two-stroke and six-stroke cycle engines.

This early Stockport vis-à-vis engine operated on what has now become known as the "Clerk" cycle, a displacer cylinder being used to draw in the charge of gas and air and to force it into the motor cylinder under pressure, so that the entering charge displaced the exhaust gases, which escaped by way of ports over-run by the motor piston. In his book, *The Gas, Petrol and Oil Engine*, published in 1909, Sir Dugald Clerk referred to the fact that a modification of his engine "was also largely made and sold by the Stockport Company." Incidentally, it may be remarked here that, in recent Cantor Lectures before the Royal Society of Arts, Clerk was twice incorrectly alluded to as the originator of the two-stroke cycle principle of operation. His engine of 1881 certainly claimed much attention in those early days, and since, but, as his own book clearly states, James Robson, of North Shields, had produced a two-stroke cycle engine in 1877 and another in 1879 "in which the front of the cylinder is enclosed and used as a pump to force gas and air into a reservoir at about 6 lb. per square inch above atmosphere; the piston overran ports in the cylinder, but the exhaust was not timed by it; a separate exhaust valve was used which opened and closed at the proper time. This engine was built by Messrs. Tangye and exhibited by them at the end of 1880." The over-running of exhaust ports by the motor piston was a feature of the Clerk engine.

It is interesting to record that, in 1886, Dugald Clerk joined the staff of Messrs. Tangye, at Birmingham; no doubt he was in full possession of Robson's previous work for that firm. A memoir of Robson, written by his son, who became Clerk's assistant at Tangyes', was published in 1915 and contains many interesting details of the work of his father, whose ability and ingenuity has somehow escaped general text-book notice.

The Stockport vis-à-vis two-stroke engine of 1887, as the illustration shows, had the displacer cylinders arranged in the lower portion of the bed casting; the compression space at the end of each motor cylinder communicated with its displacer cylinder through automatic lift valves opening into the compression space. At the outer end of the cylinder were exhaust ports, over-run by the motor piston and communicating with the atmosphere. The displacer pistons were actuated by lever and links from the power pistons, and on their forward movement drew in the charge of gas and air; the return stroke transferred the charge to the

* *Proc. I. Mech. E.*, vol. 1 page 204 (1901).

motor cylinder to displace the products of previous combustion. Mr. Bellamy states that the compression of the charge in the motor cylinder reached about 50 lb. per square inch. Ignition was effected by a slide valve operated by an eccentric, as can be readily seen in the illustration. The governing arrangement, with bob weights to act on the "hit and miss" principle, can also be easily discerned. The two big ends are disposed side by side on the same crank pin. The trigger working the mechanical cylinder lubricator is worked from the slide-valve rod. The holes in the bed indicate that the frame casting formed an air silencer.

Twelve years later (1890), the Otto patent expired and the resulting intensive competition by makers of four-stroke engines brought previous ruling prices down with a run. It became no longer possible to produce two-stroke engines of the displacer type at a profit, and this, without doubt, explains why the Stockport firm proceeded no farther with its two-stroke vis-à-vis designs. Four-stroke cycle engines were subsequently constructed in growing numbers and a demand for larger power output brought about increases in cylinder sizes and, later, a need for multi-cylinder units. Messrs. Crossley Brothers then produced vis-à-vis four-stroke gas engines and from their records it appears that two engines of this design, each developing 194 h.p., were sold to the Blackpool Tower Company in 1894. The writer well remembers that about this time, when he was a member of the staff of a competing firm, a small model was provided for demonstrating what were considered to be the mechanical defects of this particular type of construction. Nevertheless, it is now interesting to record that four vis-à-vis gas engines, each of 133 brake horse-power output, were supplied in 1896 to the Heathwall pumping station of the London County Council and that these engines were reconstructed on site 33 years later by an alteration to the throttle governor, and the fitting of new liners, pistons, breech ends, connecting rods, water jackets and electric ignition gear to bring them into line with modern oil-engine practice.

Eight gas engines of the same vis-à-vis type, four of 230 brake horse-power and four of 190 brake horse-power, were supplied by Crossley's to Lots-road pumping station, Chelsea, London, in 1902-3. Some have been replaced by modern oil engines, but new ignition blocks were supplied to suit the larger engines as recently as September, 1940—38 years later. Between 1894 and 1907, many similar engines were sold here and abroad. A full description and records of a test of a vis-à-vis Crossley gas engine, rated at 450 h.p. and supplied in 1899 to Messrs. Brunner, Mond at Winnington, near Northwich, for use with Mond gas—the first of its size to be made—are given in the paper already referred to as being presented by Herbert A. Humphrey to the Institution of Mechanical Engineers in 1901. Mr. Humphrey described it as "a workmanlike and successful engine."

One feature of Humphrey's paper was the comparison of the test results from the Crossley vis-à-vis engine and from a Premier gas engine of 500 h.p. of the positive-scavenge type, with two cylinders in tandem. At that date, James Atkinson, at Crossley's, Manchester, and the late J. H. Hamilton, at the Premier Company's works at Sandiacre, were in rivalry. To-day, as is well-known, the interests of the two firms are identical. During the discussion of Humphrey's paper, Atkinson stated that "when it was started it [the vis-à-vis engine] was the most powerful and successful gas engine in England." . . . "Personally, he felt very proud of having anything to do with it." Hamilton, usually a very reticent individual, also took part in the discussion and, *inter alia*, combated Atkinson's suggestion that his tandem design was more complicated. He considered that there was nothing to choose between the two types in this respect, and criticised the bearing area of the crankpin brasses of the vis-à-vis engine. At that time and for years afterwards, Hamilton would have nothing to do with the vis-à-vis type. He disliked the horizontally-disposed exhaust valves of the Crossley large engine design, and also the tendency to piston slap which the vis-à-vis arrangement inherently possessed.

With the passage of time, however, Hamilton was

VIS-A-VIS INTERNAL-COMBUSTION ENGINES.

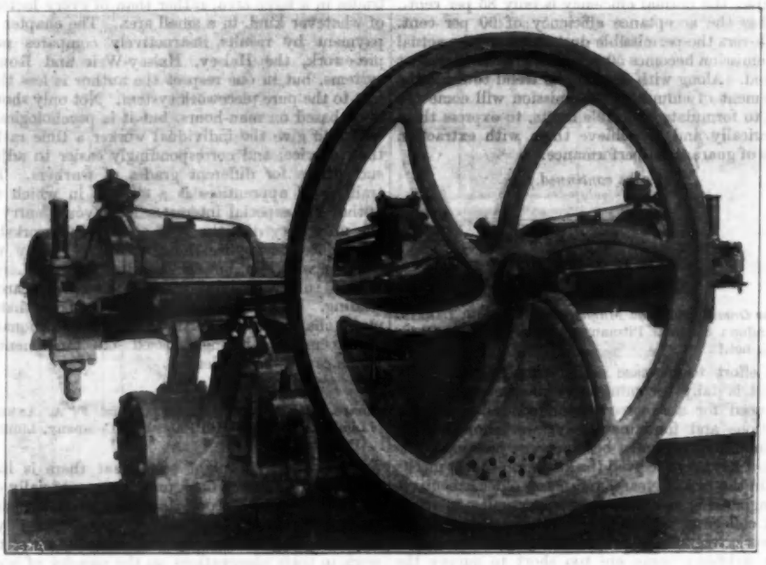
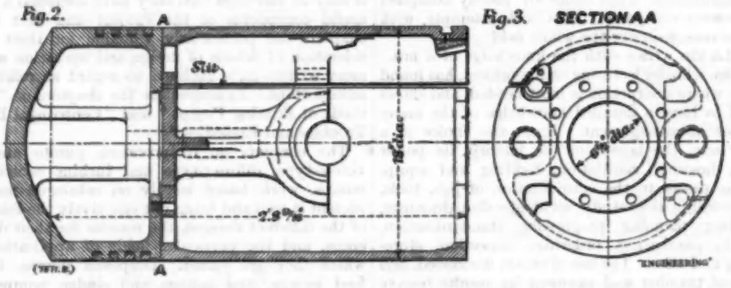


FIG. 1.



forced to consider methods which would overcome his own objections to the vis-à-vis type of construction, for, in the year 1927, after the successful development of the Crossley-Premier high-compression horizontal oil engine, he was confronted with the problem of designing ten 300/400 h.p. engines, to be coupled with ammonia refrigeration compressors, capable of being fitted within the space between decks of five motor vessels then under construction for the Nelson Line of cargo and passenger vessels. At the outset, Hamilton was loth to tackle the job, but was eventually spurred to the endeavour by the knowledge that a competitor had proposed an alternative design which he knew to be unworkable. He devised a new big-end bearing of the forked type, which would provide what he considered to be ample area for minimising bearing pressures. He had already developed successfully a vertically disposed exhaust valve, and the only real problem remaining was the avoidance of piston slap, resulting from the combination of under-running and over-running connecting rods.

Many conferences took place during the design stage between Hamilton and his principal assistant, Mr. A. C. Yeates, and eventually it was decided to make the pistons with slit skirts, so that the concentricity should not be absolute, but might be varied to suit working temperatures and the thrusts resulting from the movements of the connecting rods. Figs. 2 and 3 show sections of the piston as finally designed. The slit in the piston wall is plainly marked and it will be observed that, at the central web of the piston-pin boss, the construction is such that a tapered bush and draw bolt with locking device can be fitted. By turning the bolt a very small amount the diameter of the piston skirt can be increased a few thousandths of an inch over a large portion of its surface area. An indicator is provided to show the degree of expansion so effected. The piston on the over-running connecting rod has the slit on the upper portion of the piston skirt, while that on the under-running connecting rod has the slit below the piston pin. As a matter of interest it may be mentioned that Hamilton had thought that the position of the respective slits should be just the reverse, and it was only when trials of the engine were in progress that it was demonstrated that he had prognostigated incorrectly. The device has entirely obviated any tendency to piston slap.

The application of the Crossley-Premier vis-à-vis horizontal engine to marine service was first effected in 1928 for the refrigeration plant in the motorship Highland Monarch. Each engine had four cylinders, two on either side of the central crankshaft, the dimensions being 16½ in. diameter and 24 in. stroke. The rated brake horse-power was 310 at 180 r.p.m. For the special requirements of marine service a wide range of speed was demanded and the engine was under complete governor control from 90 r.p.m. to 180 r.p.m. by hand adjustment during continuous operation. Hamilton's success was proved by the fact that after the first round trip of the Highland Monarch it was reported that "the oil engines worked like a clock."

This, then, was the resurrection of the vis-à-vis principle, as applied to oil engines for the first time. Some three years later, in April, 1931, the writer was engaged to make non-stop trials of an eight-cylinder four-crank Crossley-Premier oil engine, rated at 1,000 brake horse-power at 214 r.p.m., and embodying Hamilton's first full-width big-end bearing with straps. This engine subsequently formed one of three similar units installed at the Middle Level pumping station at St. Germans, Norfolk. The test was taken over a period of one week's continuous day and night running. The load for six days and nights was 900 brake horse-

power and was increased for the seventh twenty-four hours to 1,000 brake horse-power. The results of the trial were satisfactory in every way. The largest vis-à-vis engines yet made are the two Crossley-Premier 16-cylinder eight-crank units, pressure charged and rated at 3,000 brake horse-power, now working at Jerusalem power station, constructed to the order of Messrs. Balfour, Beatty and Company, Limited, and another of equal output for Messrs. Stewarts and Lloyds.

In July, 1935, the writer was engaged to make an independent report on a four-cylinder two-crank vis-à-vis oil engine at the works of the Messrs. Brush Electrical Engineering Company, Limited, Loughborough. This was rated at 250 brake horse-power at 250 r.p.m., and was one of 20 since constructed to the order of the Blue Star Line for direct coupling to refrigerating compressors in marine service. The design had been originally introduced about a year earlier under the supervision of Mr. H. V. Senior and is now known as the Blackstone-Brush type. This engine also had an abnormal speed range under hand control for the special purpose of marine refrigeration plant, namely, from 125 r.p.m. to 250 r.p.m., and the means provided for varying the timing of the fuel injection to suit the lower speeds enabled the rate of fuel consumption per brake horse-power per hour to remain practically uniform over a wide range of speed.

This article has been concerned only with British practice and it should be mentioned that the Otto-Deutz Company, of Cologne, were also making vis-à-vis gas engines contemporaneously with Crossley Brothers. It seems desirable, however, to place on record what has been done in this country to develop this type of engine, in the interests of future generations of internal-combustion engineers.

THE USE OF CAST IRON IN BUILDING.*

By S. B. HAMILTON, M.Sc., A.M.Inst.C.E.

(*Continued from page* 406.)

JOHN RENNIE (1761-1821) installed in London a workshop for making all sorts of machinery, and in this shop tests were made of materials and devices which he proposed to use on public works on which he was engaged. Here his sons, George (1791-1866) and John (1794-1874) received their shop training. The testing-machine which George Rennie described in his *Account of Experiments on the Strength of Materials*, in the form of a letter to Dr. Young, published in *Phil. Trans.* for 1818, was constructed to enable him, in addition to routine testing, to extend the knowledge of the strength of materials. It could apply a load of 25,000 lb. In particular, he claimed to have made on this machine the first accurate tests to determine the crushing strength of cast iron. The novel features of Rennie's testing-machine were the mounting of the fulcrum anchorage and the specimen support on a substantial cast-iron bed-plate; and the provision of hardened steel bearing-plates between which the specimen could be crushed. The use of a fulcrum-pin, instead of a knife-edge, introduced friction, and a slight uncertainty as to the leverage. From the point of view of precision, this feature marks a retrogression from Jean Rondelet's machine of about 1780, where knife-edges were provided throughout, and screw adjustment was first applied. Rennie's machine was a substantial workshop model upon which many useful tests were made.

Now, whereas ductile materials squeeze out laterally under pressure, brittle materials either crack roughly in the direction of the load applied, or split along inclined planes, making fairly definite angles with the direction of the compressive force. The longitudinal cracks are due to lateral tension—an invariable accompaniment of longitudinal pressure; the inclined slip planes mark the direction of maximum shear stress. Cast iron fails under pressure by bursting sideways. These phenomena had been noted by earlier investigators; but the first clear explanation of them was given by Vicat in a paper entitled *Recherches expérimentales sur les phénomènes physiques qui précèdent et accompagnent la rupture ou l'affaissement d'une certaine classe des solides*, published in the *Annales des Ponts et Chaussées* for 1833.

The first definite contribution to knowledge of the behaviour under load of cast-iron beams was due to the labours of Eaton Hodgkinson (1789-1861) and Sir William Fairbairn (1789-1874). Fairbairn was commissioned in 1824 to build fire-proof mill-buildings for Messrs. Gott, of Leeds, and a Mr. Wood, of Bradford. He was not satisfied that either the narrow Tee-section used in 1800 by Boulton and Watt or the I-section recommended by Thomas Tredgold (1788-1829) was the strongest obtainable with a given weight of metal. Tredgold had made some experiments several years earlier and reported the results in the second edition (1824) of his *Practical Essay on the Strength of Cast Iron*, but had failed to disprove his erroneous assumption that cast iron was as strong to resist tension as it was to resist compression. For the Leeds building, Fairbairn used beams of 14-ft. and 16-ft. span, but for the Bradford building, after testing experimental beams, he boldly increased the span to 20 ft. and made his beams of a section like the profile of a collar stud, 18 in. deep at mid-span and graded off to 11½ in. deep at the bearing.

Hodgkinson's work on cast-iron beams was reported to the Literary and Philosophical Society of Manchester, and published in their *Memoirs* (2nd series): 1. *On the Transverse Strength of Materials* (read 1822), and 2. *Theoretical and Experimental Researches to Ascertain the Strength and Best Form of Iron Beams* (read 1830). In the earlier paper, Hodgkinson added nothing of importance to the theory of bending. Like Coulomb, he realised that the fibre of beams of such materials as timber both stretched and compressed; but, also like Coulomb, he considered that beams of hard brittle materials were practically incompressible, and behaved in accordance with Mariotte's hypothesis, which placed the neutral axis at or close to the surface of the compression side of the beam.

Coulomb had clearly realised that the total compressive and tensile forces acting in the fibres of a bent beam were equal; but some later writers (such as A. Duleau, in France, and Peter Barlow, in England) had misinterpreted him as suggesting that the moments of these forces about the neutral axis were equal. Hodgkinson recognised this error as such; and, by experiment, satisfied himself that tensile and compressive strain were equal for equal stresses, thus confirming Hooke's Law, although, in common with most students of the subject for the previous century and a half, he made no mention either of Hooke or of his Law. Even Coulomb, when he brought his great knowledge and original mind to bear on the subject, did not seem to have heard of Hooke. It was Dr. Thomas Young who both resuscitated Hooke's renown, and forced the notable work of the great French engineers and physicists of the Eighteenth Century on the attention of British scholars; but Young's own work was difficult reading, only percolating into the minds of the next generation of students through the works of such teachers as Professor John Robison and Dr. Whewell.

Though cast iron possessed, at least under moderate loading, equal elasticity in tension and compression, it was far from being equally strong to resist tensile and compressive stresses. Hodgkinson demonstrated this effectively by testing Tee-sections in bending with the table first on the convex, then on the concave side, finding the relative strength of cast-iron specimens in the two cases to be as 4 to 1, although no difference was found when similar wrought-iron specimens were similarly tested. To carry out experiments on a larger scale, Hodgkinson needed more powerful testing plant and financial backing than he possessed. A Mr. Ewart, probably Peter Ewart (1767-1842) introduced him to Fairbairn and Lillie. Hodgkinson's later work was carried out in close collaboration with Fairbairn, who provided both the machinery and the specimens required to continue his investigations.

According to Fairbairn, the relative strengths, for equal weight of metal, of the beams hitherto mentioned could be expressed as ratios to that of Hodgkinson's ideal section, in reversed chronological order, thus:—

Hodgkinson (1830)	1·00
Fairbairn (1825)	0·75
Tredgold (I-section) (1824)	0·62
Boulton, Watt and Company (1801)	0·54

Fairbairn stated that bridge girders up to 40 ft. span in a single casting might be constructed with safety if proper precautions were taken in the moulding; and that beams of 76-ft. span had on one occasion been made in single castings in this country, and shipped to Amsterdam for use on the Haarlem Railway. When design or construction was undertaken by ignorant persons, however, there was serious risk of accident. Fairbairn was called in to diagnose several such failures.

A cotton-mill in Oldham collapsed in October, 1844, killing 20 people. The building was carried on cast-iron columns supporting beams of just under 14-ft. span. At the gable end of the mill, secondary beams spanning 15 ft. 3½ in. brought concentrated loads to bear on the last row of main beams, which were stressed, according to Fairbairn, to 90 per cent. of their breaking load. The rise of the arches between the main beams was 12 in., which Fairbairn considered too little; not less than 1½ in. per foot of span should be allowed. Also, the tie-rods were placed on top of the beams, 18 in. from the bottom flange; tie-rods, he contended, should never be higher than the soffits of the arches. The columns were too slender and of varying thickness, owing to bad coring.

Another failure was described by Fairbairn before the Institution of Civil Engineers in 1847. Gray's cotton mill, in Manchester, possessed a flat roof used as a tank and carried on cast-iron girders of 32-ft. span, strengthened by trussing. Fairbairn reckoned that the load borne by the girder was 94 per cent. of the calculated breaking load. One beam failed in compression: the rest followed. Fairbairn recorded and illustrated some details of beams and connections according to the best practice of his day. The tie bars provided to relieve the beams from the thrust of the floor arches were members of great importance. Sometimes, as in Benyon's Mill in Leeds, these were screwed at the end; sometimes the bars were forged to a gib end, two from adjacent spans passing through the same hole, where they were retained by a cotter. In Benyon's Mill an iron ring held adjacent beams together at a column head. Another method of using iron rings was to pass them over half-bosses cast at the sides of the beam ends where these embraced the column, as in flywheel construction. Hodgkinson recommended beams with parallel flanges of constant thickness but varying width, parabolic in plan, as saving 30 per cent. of the metal required when the section necessary at mid-span was carried through the whole length.

The customary size of columns in mill buildings was 6½ in. to 7 in. in diameter, to carry beams up to 18-ft. span, and 8 in. diameter up to 25-ft. span, the thickness of metal being reduced from 1⅛ in. in the lower part of the building to ¾ in. in the upper storeys. These dimensions were empirical; no adequate theory of columns was yet in existence. Leonhard Euler (1707-1783) had shown in 1757 that a long thin compression member of uniform section, of homogeneous material, was liable to deflect suddenly under a calculable critical load. Its resistance to buckling in this manner was found to depend on the elasticity of the material, and on the shape of its section; the crushing strength of the material did not appear in Euler's equation at all. Euler's equation was a most important contribution to the theory of elastic structures, but its fundamental assumptions were never realised in the actual columns of buildings. Coulomb therefore rejected it. Robison dismissed Euler's paper as "a dry mathematical disquisition." Peter Barlow regarded the theory as inapplicable to the materials and conditions of actual practice, but could suggest no useful alternative. The subject was too important for continued acquiescence in this negative attitude and, in order to establish working rules for the design of pillars, Hodgkinson conducted a series of experiments on solid compression members of lengths from 1 in. to 5 ft., and diameters from ½ in. to 2 in., and on hollow members of lengths up to 7 ft. 6 in. and diameters up to 3½ in.

The critical load calculated from Euler's equation could not apply to very short columns, since for these it was greater than the crushing strength of the material, which was obviously absurd. Hodgkinson found, however, that Euler's equation agreed reasonably well with experimental results for very long slender columns. Hodgkinson tested some of his columns with carefully rounded ends; others terminated in large, flat discs, which compelled the columns to retain their axial direction at both ends. By Euler's theory the flat-end columns should have been four times as strong as round-ended columns of the same length and cross-section. Hodgkinson found them a little over three times as strong. Columns of equal length, with the same end conditions, and of geometrically similar cross-section, should develop resistance, according to Euler, in proportion to the fourth power of their diameters. Hodgkinson found that an index of 3·7 best fitted his experimental results; but he still had difficulty in arranging his formula so that for short, stout puncheons the resistance given would be the same as the crushing strength of the material. No amount of "wangling" with indices and constants alone could disguise the fact that two separate tendencies to failure were always present in greater or less degree, and that their combined effect approximated to the harmonic mean between the resistances to buckling and to crushing. Hodgkinson eventually produced a formula on these lines. Lewis D. B. Gordon, the first Professor of Engineering at the University of Glasgow, and W. J. Macquorn Rankine (1820-1872), who followed Gordon in that chair, improved its form, and as Rankine left it, the column formula remained standard as long as columns were made in cast iron.

(*To be continued.*)

* Paper read before the Newcomen Society, in London, on Wednesday, April 23, 1941. Abridged.

ROAD BUILDING IN TURKEY.—Some 3,000 km. of new roads have been built in Turkey since the establishment of the Republic, and out of this total, 735 km. were completed during the year ending October 31, 1940.

RECENT APPLICATIONS OF FLUID COUPLINGS.

THE short account given below of some recent applications of fluid couplings for power transmission may be regarded as, to some extent, supplementary to the exhaustive paper read by Mr. Harold Sinclair before the Institution of Mechanical Engineers and entitled "Some Problems in the Transmission of Power by Fluid Couplings." A fairly full and illustrated abridgment of this paper was given in ENGINEERING, vol. 145, page 487, *et seq.* (1938), but, although the paper dealt adequately with principles and construction, the field of application has widened considerably since it was read, and so may now be briefly re-surveyed by referring to some typical installations made in 1940. Some attempt has been made at classification in this article, and, where a size is mentioned by a number, it should be explained that the figures employed indicate the outside diameter in inches of the working circuit of the coupling.

The transmission of power in winch operation is often difficult, as overloads are frequently met with, due to the material being hauled striking an obstruction. A case in point is in drag-line scraper practice, now often employed in coal handling at gas works, power stations, etc., the particular winch arrangement varying with the conditions. A typical installation is shown in the accompanying illustration. This view shows the winch drums of the Beaumont drag-scraper gear installed by Messrs. International Combustion, Limited, 19, Woburn-place, London, W.1, for the coal-handling scraper at a new power station of Messrs. Edmundsons Electricity Corporation, Limited. As will be seen, the fluid coupling, which is of the rigid traction type, size 23, is mounted between the motor shaft and the driving pinion. The motor is of 125 h.p. and runs at 960 r.p.m. The drag-scraper bucket has a nominal capacity of 5,000 lb. and the plant is designed to deal with 120 tons of small coal per hour over an average haul of 185 ft., operating at rope speeds of 470 ft. per minute in both directions. Any sudden overload, which would otherwise be transmitted to the motor, is effectively damped out by the fluid coupling and there is, in consequence, considerable reduction in the wear of the mechanical parts and ropes. Another application is to a drag-scraper winch for Messrs. Stratford Engineering, Limited, Johannesburg, the drag-scraper being commonly employed in the South African gold mines for handling ore. The coupling, which is of the traction type, size 16·25, is used on the transmission system of a 60-h.p. reversible squirrel-cage motor running at 1,430 r.p.m. As this contract is not yet completed, particulars of performance cannot be given, but it is known that the smooth acceleration and jerkless operation of the fluid coupling will prevent the present extreme overloads on the equipment; this coupling is the first to be put into service in this branch of the gold-mining industry. An interesting point is that the fluid coupling serves to isolate completely the inertia of the motor, which would otherwise cause severe overloading of the winch gear and ropes when an immovable object is struck.

Another winch application is in the Canadian lumber industry, winches being used for hauling heavy logs. Two rigid traction-type couplings, size 14·5, were supplied to Messrs. Hamilton Bridge Western, Limited, Vancouver, B.C., and were originally intended for a logging winch driven by two Ford-Mercury engines. Two independently-driven winches were, however, installed, each winch having one of the fluid couplings, a friction clutch and a four-speed gearbox. The Mercury engine used for each winch develops 71 h.p. at 2,200 r.p.m. That the fluid couplings have met successfully the difficult conditions imposed is shown by a report from the engineers at the site on their working. This report states that the winches operate at a gear higher than winches without fluid couplings and that the amount of work done is increased by 30 per cent. Gear-changing now averages less than once per load, as against four times to six changes per load, and the take-up of the load is very smooth. When logs are being handled in the stackyard and if the load comes up against some obstruction, the engine operating a winch equipped on conventional lines may be stalled before the operator can release the friction clutch. The fluid coupling has eliminated this difficulty and has made easier such gear-changing as may still be necessary. A lift of 4,000 lb. can be held or lowered at will by manipulation of the engine throttle. Whipping or snatching of the hauling rope has been eliminated and the consequent wear and tear on the tackle has been greatly reduced.

An application of the fluid coupling which is comparable with its use with winches, in that the loading is intermittent and ropes are involved, is its employment in grab dredging. A size 26 traction-type coupling has been fitted to a Diesel-engined grab dredger made by Messrs. Priestman Brothers, Limited, Hull. The Paxman engine used is rated at 300 h.p. when running at 1,130 r.p.m., and transmission to the several motions is effected through individual friction clutches. As most of the slip required during the engagement of these clutches is transferred to the fluid coupling on the main drive, the wear on the clutches will be greatly reduced. In a grab dredger of the size concerned, the operation of the slewing motion presents a rather difficult problem, since this motion has to be started with the load swinging at the end of a long boom. A sudden start naturally aggravates the swinging and the smooth take-up of the fluid coupling should present a distinct advantage in overcoming the difficulty.

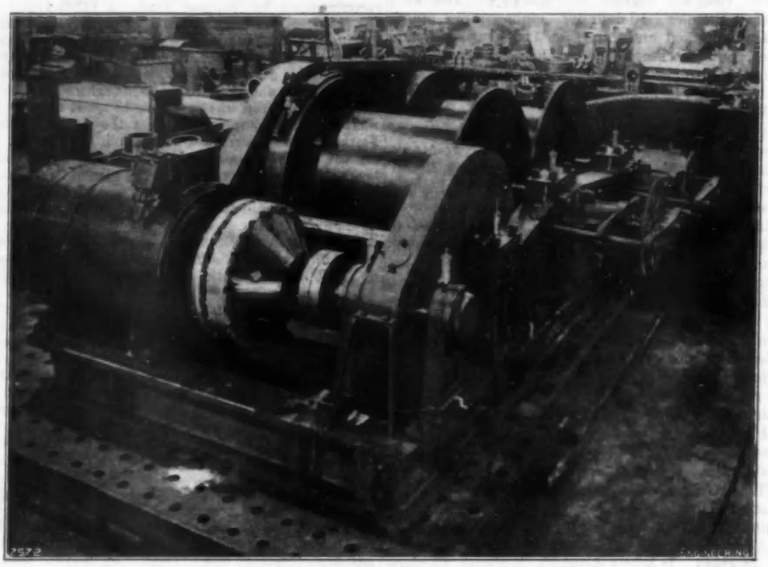
In a fan drive installation of considerable interest, a size 32 scoop-controlled coupling, rated at 670 h.p. at 1,160 r.p.m., is employed. The fan is used in connection with an aeronautical laboratory in Canada, the fan having been constructed by Messrs. Canadian Sirocco, Limited, Windsor, Ontario, and the coupling having been supplied through Messrs. The Crude Oil Engineering Company, Limited, Montreal. As the fan draught is required to be controlled within precise limits for purposes of scientific investigation and in temperature conditions ranging from —40 deg. F. in winter to 100 deg. F. in summer, the fluid coupling enables the necessary fine speed control to be obtained. Incidentally, its adoption served to reduce the capital outlay and to enable simpler equipment to be employed than with the method of driving by a variable-speed motor. A somewhat unusual fan drive was one recently supplied to Messrs. Birmingham Electric Furnaces, Limited, Birmingham. The traction-type coupling here fitted was not interposed between the driving motor and the fan, but is fitted on a main shaft driven by a 45-h.p. motor, from which shaft transmission to the battery of six fans is by Vee-belts. When starting up, the air is cold and in this condition the fans, if directly coupled, would require considerably more power than the rated capacity of the motor. The power required by the fans falls off, however, as the furnace temperature rises, the function of the fluid coupling being to compensate from the drop in load by a corresponding reduction in slip, the speed of the fans thus being automatically increased from 87 per cent. of full speed to 97 per cent. of full speed.

In the mechanical handling of materials the fluid coupling has been successfully employed for some time, largely on conveyor installations. A recent application is to bucket elevators, a fluid coupling having been supplied to Messrs. Babcock and Wilcox, Limited, London, for this purpose. The elevator is driven by a direct-current motor developing 13 h.p. at 900 r.p.m. The bucket elevator, though generally giving little trouble apart from maintenance, is liable at times to sudden stoppages from jamming or other forms of obstruction. To meet this contingency, the main function of the coupling is to limit the torque transmission to 2·5 times the full-load torque. If desired, the maximum torque can be varied by adjusting the filling of the coupling. With elevators driven by alternating-current motors, a fluid coupling also enables the full torque developed by a standard squirrel-cage motor, when up to speed, to be used at starting, this being also an advantage when driving a belt conveyor. In such cases a simple direct-on starter would be fitted. Apart from bucket elevators and belt conveyors, coal is not infrequently handled by a jigger conveyor, that is, a conveyor, which, though consisting of what is in appearance a belt in a trough, is reciprocated with a short stroke, the material progressing along the conveyor by its forward momentum as the return stroke commences. This intermittent motion does not, however, preclude damage due to stalling caused by coal blockage. The London Midland and Scottish Railway Company, during the year, has contracted for four size 12·75 traction-type fluid couplings for use in connection with the jigger conveyors for a new coaling plant. These couplings, supplied through Messrs. Henry Lees and Company, Limited, Mother-well, each transmit 10 h.p. at 970 r.p.m., and are designed to stall at 1·9 times the full-load torque.

Some new applications have been made recently in connection with electric cable manufacture, both of the power and telegraph types. Messrs. Johnson and Phillips, Limited, London, who, as is well known, manufacture, in addition to cables, equipment for marine cable laying, have now applied fluid couplings to their transportable cable-hauling apparatus used for transferring cable from one tank to another. Previously these units were generally constructed for use on board ship, where the available power supply is either steam or direct current. Recent requirements have, however, necessitated dockside operation on sites where the power supplies just mentioned are not always available. The use of the scoop-controlled coupling enables alternating current to be employed with simple squirrel-cage motors for the drive, such current being generally available. The infinitely-variable speed regulation provided by this type of fluid coupling enables the hauling speed to be adjusted to suit the size of cable being handled. The apparatus is mounted on wheels and is not only neat and compact, but is not likely to give trouble in operation since the variable-speed transmission gear is of a robust nature. Messrs. Johnson and Phillips have also made extensive use of the fluid coupling in the drives of cable-making machinery. The first application of the rigid traction coupling to bunching and stranding machines was made towards the end of 1939, and has been followed by its adoption on laying-up, braiding and trapping machines. It is understood that the fluid coupling has proved a considerable asset to machines of these types, since it gives a smooth start and uniform rapid acceleration without jerk or snatch.

The employment of the fluid coupling in railway traction, though of about ten years standing, has continued to progress. Incidentally, we are informed that, during the year prior to the outbreak of war, 60 per cent. of the annual construction throughout the world of Diesel-engined locomotives above 65 h.p. embodied fluid transmission. As far back as 1930, Messrs. Hudswell, Clarke and Company, Limited, Leeds, built for export to Chile a 300-h.p. Diesel mechanical locomotive with a ring-valve traction coupling. Subsequently this firm installed in a Diesel-engined locomotive the first traction coupling having

FLUID COUPLING ON DRAG-SCRAPER WINCH.



STANDARDISED UNIT BRIDGE.

MESSRS. THE BUTTERLEY COMPANY, LIMITED, RIPLEY, NEAR DERBY.

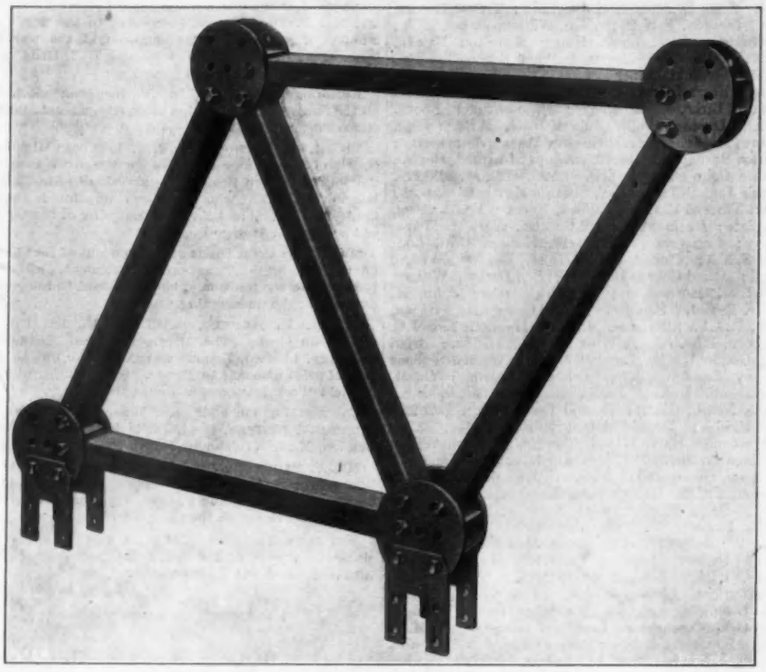


FIG. 1. TWO PANELS OF GIRDER ASSEMBLY.

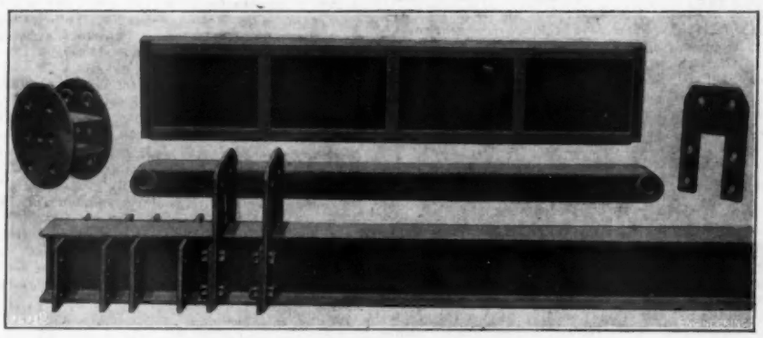


FIG. 2. SET OF STANDARD MEMBERS.

THE BUTTERLEY STANDARD BRIDGE.

THE importance of bridge material prepared so that it can be readily transported and rapidly erected is so evident in these days, when a temporary structure may be required anywhere at any time, that it need not be emphasised. We give below some particulars of a new design for such bridges, which has been provisionally patented by the manufacturers, Messrs. The Butterley Company, Limited, Ripley, near Derby. The material for both light footbridges and those of wide span for heavy loads is made up of standard units, which are seen assembled in Fig. 1, the five components being illustrated in Fig. 2; five components are required for heavy bridges, while four suffice for a footbridge. The characteristic feature of the girder design is that the chords and diagonal members are identical, and are arranged in isosceles triangles with intersections at 10-ft. centres. All the standard units are made to precise jigs and are individually interchangeable. A uniform bolt, 2-in. in diameter, is used for all connections. The bridges may be erected either with the deck below the level of the bottom chord, the so-called "through" type, or below that of the top chord, the so-called "deck" type.

The standard chord and diagonal member seen in the centre of Fig. 2 is of closed box-section, measuring 8 in. by 6 in. externally and 9 ft. 4 in. long between the centres of the end holes. The material is steel, $\frac{1}{4}$ in. thick, and the box section is made up of two strips bent into angle-iron form longitudinally, and welded together along the two seams resulting from their juxtaposition. The eye at each end is formed from round bars $5\frac{1}{4}$ in. in diameter by $8\frac{1}{4}$ in. long. These are welded into position transversely, two of the faces of the box section being bent over and welded in with a butt joint at the extreme ends. The bars are drilled with holes to take the standard bolts. The three holes seen along the sides of the members are for use in erection, the deformation of the member as these points being prevented by welded tubular distance pieces spanning the cross-section. The chords and diagonals are connected by the drums or bobbins seen at four points in Fig. 1 and in greater detail on the left of Fig. 2. The side plates are 1 ft. 11 in. in diameter and are spaced 8 in. apart, being connected by a pair of welded plates, between which the chord members enter. The plates are drilled for 2-in. bolts, the holes being compensated for by welded bosses on the inside. To each intersection point along the bottom chords for "through" bridges a pair of inverted U-shaped plates are bolted to the bobbins, as shown in Fig. 1, a single plate being seen on the right of Fig. 2. These carry the cross-members supporting the deck and tying the two main girders together.

One end of a cross-member is seen at the bottom of Fig. 2. As standardised for road bridges, it consists of a rolled-steel joist, 20 ft. long and of 15 in. by 6 in. by 45 lb. section. On each side of the cross-member and at both ends are welded six vertical plates grouped in three pairs. The purpose of these will be evident from the fact that to the innermost pair are bolted two of the U-plates mentioned above, the method of securing the cross-members to the bobbins being thus clear. With the plates in this position, the transverse distance between the centres of the girders is 12 ft. $7\frac{3}{4}$ in. The deck is formed of $\frac{1}{4}$-in. steel chequer plate with side and end flanges and welded crossbars at intervals. The standard deck members are 10 ft. long by about 2 ft. 6 in. wide by 6 in. deep. One of them is seen, as viewed from the underside, at the top of Fig. 2. It will be noticed that the ends are joggled so as to fit on the cross-members, and from their length it will be evident that they are laid longitudinally. The actual width is such that five of the units will fit snugly in between the side girders when these are at 12-ft. $7\frac{3}{4}$-in. centres. There are no bolted connections, but on road bridges a kerb is formed on top of the deck by standard chord members laid at each side against the girders and secured by bent bars passing through the end holes. This arrangement gives a clear roadway of 10 ft. 6 in.

It might be inferred that, since the cross-members are 20 ft. long and that three sets of bracket plates are provided at each end, the roadway could be made wider by using the outer brackets. This, however, is not the purpose for which these brackets have been designed; their object is to enable the loads and spans to be varied widely by using two girders or even three girders at each side. These additional girders are, of course, identical with the standard units, and the two, or three, adjacent girders are coupled transversely by bolts through the centre hole in the bobbins, distance pieces being fitted between the girders. The provision of the extra brackets obviously renders it easy to strengthen a bridge if heavier loads than were originally anticipated have to be provided for, apart from enabling different loads to be arranged for initially. In addition, the load-carrying capacity of the bridge can be increased by a second row of units arranged vertically, one above the other, thus making the side girders

an idling drag eliminator and traction-type gearbox, and thus established the principle of maintaining tractive effort during the intervals of gear-changing. Messrs. Hudswell, Clarke recently ordered five size 23 scoop-controlled couplings rated at 165 h.p. at 1,150 r.p.m. for Diesel-engined locomotives for a leading oil company. These couplings are to work in conjunction with four-speed S.S.S. (synchro-self-shifting) traction gearboxes. Drag torque is eliminated by the emptying of the working circuit of the scoop-controlled coupling and hence the idling drag eliminator used with the traction coupling becomes unnecessary, and, furthermore, the gland is eliminated. The S.S.S. gearbox has been developed for use on locomotive transmissions and the gears are, as already indicated, self-shifting, intricate "servo" actuating mechanism being also eliminated.

Two further illustrations of the adaptability of the fluid coupling may be mentioned in conclusion. The first of these is the fitting of two size 29 rigid traction couplings to Diesel engines made by Messrs. Blackstone and Company, Limited, Stamford. These engines develop 80 h.p. at 600 r.p.m. and are employed in driving bore-hole pumps. Transmission is by means of bevel gears and a fluid coupling, the latter providing a light starting load for the engine and preventing the transference of torsional oscillations to the bevel gears. Moreover, the engine is protected in the event of the pump and gear becoming stalled. The final example is that of a small installation only, consisting of two size 10·5 fluid couplings. These have been supplied through Messrs. Underhill, Day and Company, Limited, Brisbane, for the Brisbane City Council. The machines involved are mechanical screens and the couplings are of the rigid traction type. They provide easy starting conditions for the 1·5-h.p. squirrel-cage motors and the torque-limiting characteristic should prove of value if the screens stall.

All the fluid couplings referred to above have been manufactured by Messrs. Hydraulic Coupling and Engineering Company, Limited, Fluidrive Works, Worton-road, Isleworth, Middlesex. The present output of fluid couplings manufactured under Vulcan-Sinclair patents, including Daimler Fluid Flywheels and Chrysler fluid drives, aggregates over 50,000 h.p. a day.

MINERAL PRODUCTION IN QUEBEC.—During the first two months of the present year 175,095 oz. of gold and 230,806 oz. of silver were produced in the Province of Quebec, as compared with 164,112 oz. of gold and 176,448 oz. of silver in January and February, 1940.

double the original depth. It is hardly possible to enumerate the various combinations available, but some examples may be given. A bridge for ordinary light loads and having a span up to 80 ft. would be erected with a single girder each side, as shown in Fig. 1. With a heavier load, of 0·75 ton per foot run, this construction would be suitable for spans up to 60 ft. For spans between 60 ft. and 80 ft., two girders on each side would be needed, while further increases, up to 100 ft., would need three girders on each side. For still longer spans, the double-depth, or two-tier, girder construction meets requirements most satisfactorily; thus for a span of 120 ft. there would be two girders on each side, both of double depth, and for a span of 150 ft., three two-tier girders on each side. Other arrangements can be readily visualised; for instance, a very long bridge could have intermediate trestles built up of the standard units.

Several points hitherto only briefly touched upon may be conveniently amplified here. The first of these is the construction for foot bridges. Clearly for these no great strength or stiffness is required in the cross-members and so standard box-section chord and diagonal members are substituted for the rolled-steel joists. The connection with the side girders is made by means of a mild-steel bracket and standard bolt to the inverted U-plates. The second point refers to the deck type bridge. The cross-members can obviously be suspended from the top intersections just as conveniently and effectively as from the bottom ones. The holes drilled in the extreme ends of the cross-members, and visible in Fig. 2, are for the attachment of handrailing or gangways should these be required. The deck can equally well be situated centrally, as regards height, in the two tier construction; that is, there would be one girder below it and one above it. The standard bolts are all of turned mild steel with ordinary nuts and split cotters. The heads of the bolts passing through the U-plates are made of a distinctive shape to facilitate identification by touch in a defective light, since these bolts are longer than the others.

The erection and launching of a bridge across a gap are both straightforward, and do not call for any lengthy description. Erection is generally carried out by assembling the several panels on one bank of the river or other gap to be spanned. A suitable erection derrick is a mild-steel tube, 20 ft. long by 2 in. in diameter, secured to one bottom chord and one diagonal by means of bolts through the holes in them previously referred to. When one bay has been erected the derrick is dismantled and moved forward for the erection of the next bay. The operation of launching may be carried out in a number of ways, dependent to some extent on the type of bridge erection, the most suitable technique for particular constructions having been worked out in detail. Roughly speaking, the bridge is built longer than is required for the span and the end most distant from the near bank is either ballasted with floor members and other spare parts, or made with two-tier construction, so that the centre of gravity of the whole mass lies some distance inwards from the bank. Small rollers attached temporarily to every other one of the lower bobbins on each side, rest on tracks placed so as to give the correct alignment to the bridge. The structure is then run across the gap by means of a winch at the rear with its rope led round a snatchblock, placed on the edge of the near bank, and returned to the end of the bridge adjacent to the winch. When the other end of the bridge has reached its abutment on the far bank and has been adjusted in position, the rear portion of the structure, which was added to prevent the front portion from tipping downwards as it was cantilevered out, is dismantled and removed.

This brief description does not apply in all cases; the procedure may have to be altered, for instance, if there is not room on the near bank to erect the whole span of the bridge, plus the balancing portion, before launching. Although the conditions of possible emergency obtaining at the present time make the design likely to prove of particular service, it will be clear that its utility is not restricted to such conditions. Bridges of this type would also be useful in developing countries abroad.

X-RAY ANALYSIS IN INDUSTRY.—We are informed that, on the invitation of Sir Lawrence Bragg, F.R.S., President of the Institute of Physics, a series of papers dealing with X-ray analysis in industry is being prepared and published in two special issues of the *Journal of Scientific Instruments*. The first group of papers deals with the applications of X-ray methods to a wide range of industrial problems and is published in the May issue. The second group deals with the technique of these methods and will be issued in two or three months' time. Copies may be obtained, price 2*s.* 8*d.* each, post free, from the Secretary, the Institute of Physics, The University, Reading, Berks.

INSTITUTION ELECTIONS.

INSTITUTION OF ELECTRICAL ENGINEERS.

Graduate to Associate Member.—Bernard Horace Akers, Pontefract; William Thomas Andrews, London, S.E.3; Arthur Newton Arnold, London, S.E.18; Hedley Jesse E. Anscombe, Brighton; Trevor Gordon Baird, London, S.W.20; Alan William Baker, B.A., Manchester; Elec. Lieut. Henry Hamilton Balean, R.N.V.R., London; Ernest William Batho, London, N.W.10; Harold Jenner Beard, B.A., Newcastle-upon-Tyne; Robert James Beard, London, S.W.4; Kenneth William Birks, Birmingham; Eric Stuart Booth, M.Eng., Leeds; Philip Robert Bray, M.Sc. (Eng.), Harrow, Middx.; Harold Godfrey Brown, Manchester; Maurice Barnard F. Burrell, Bishops Stortford, Herts.; Edward Colin Cherry, M.Sc. (Eng.), Harrow, Middx.; Francis James Clark, B.Sc., Cheadle Heath, Stockport; Stuart Vincent E. Clark, Cuffley, Herts.; Frank Clegg, Rochdale; Reginald Edward Cornish, Worcester Park, Surrey; Christian Frederick Dietrichsen, B.A., London, S.W.3; Claude Urling Doré, Rio de Janeiro, Brazil; Alfred George Douglas, B.Sc., Derby; William Earnshaw, Rotherham; Captain Arthur John M. Fisher, Bexhill; Squadron Leader George Henry Foss, B.Sc., R.A.F., Stanmore, Middx.; Kenneth Lionel C. Freeborn, B.Sc. (Eng.), West Drayton, Middx.; Brian Craig Godbold, B.Sc., London, N.W.7; Wilfred Wallace Grimes, London, E.7; Brian Carwardine Guest, Rawalpindi, India; David Glanville Gwyn, B.Sc. (Eng.), Neath, Glam.; Ronald Leslie Hales, Teddington, Middx.; Donald Alfred Hart, London, N.21; James Ernest Hart, Wirral, Cheshire; Joseph Wilson Hemingway, Sheffield, 7; Henry Coleridge Hitchcock, Cranham, Gloucester; Thomas Allwright D. Honnor, London, E.C.2; George John McDonald, B.Sc., Danbury, Essex; Henry Albert Matthey, London, N.7; Sudhir Chandra B. Mazumder, B.Sc., Hubti, India; Kean William O'Hara, Stretford, Manchester; Ernest Henry Palmer, London, N.W.10; Lieut. Joseph Donald Parker, B.Sc., Royal Signals; William Frederick Parker, London, N.W.9; Bruce Sydney Pelton, B.Sc. (Eng.), Birmingham; Laurence Herbert Pickard; Prestwich, Manchester; Leslie Sylvester Piggott, M.Sc. (Eng.), Southsea, Hants.; Major George Neil Preston, R.A.O.C., London, S.W.1; Robert Hesketh Purden, Solihull, Birmingham; Tom Ralph, Didsbury, Manchester; Krishnaswamy Ramamurti, M.A., Triplicane, Madras, India; Ranajit Chandra Sen, B.Sc., Lucknow, India; Philip Ellis Simmonds, Leeds; Shiva Nandan P. Sinha, Saugor, C.P., India; Robert Wood Sloane, B.Sc., M.A., Ph.D., Wembley, Middx.; George Ernest Smith, Bromley, Kent; Cecil Stanley Tabb, Plymouth; Richard Prestridge E. Tabb, Stafford; Cecil William Taylor, Shefford, Beds.; Lawrence Forbes Tuff, Edinburgh; Edward Francis D. Webb, B.Sc., Haywards Heath, Sussex; John Whitehead, Oldham; Francis Alan Widdup, B.Sc. Tech., London, S.W.2; Kenneth Alfred Williams, Urmston, Manchester; Herbert Brian Wood, B.Sc., Sheffield; Frank James Worland, Slough, Bucks; Peter Weston Yates, B.Sc., Batley.

INSTITUTE OF TRANSPORT.

Member.—Charles Norwood Anderson, Southampton; Harold Muscroft, Huddersfield; Leo Henry Kent Neil, London; Alexander Balmain Bruce Valentine, London.

Associate Member.—Alan William Baker, Manchester; George Stanley Ewens, Barking; William Robertson Flight, India; Lawson Walton Morton, Leeds; John Drake Parker, Guildford; George William Quick Smith, London; Pierre Johan Hendrik Theron, South Africa; Stanley Howard Adcock Thompson, Leicester; George Ronald Valli, London.

IMPORTATION OF DRILL STEEL INTO SOUTHERN RHODESIA.—The Government of Southern Rhodesia has issued an Order entitled Import (Drill Steel) Order, 1941. This prohibits the importation into Southern Rhodesia, except with the written permission of the Controller of Supplies, of ¼-in. hollow hexagonal drill steel.

"THE CHINA MAIL."—We have received from the publisher of *The China Mail* (Mr. Gordon C. Burnett, Windsor House, Victoria, Hong Kong), a copy of the issue of January 20, 1941, containing a 96-page supplement marking the centenary of the Colony's establishment in 1841. Among the numerous special articles are a detailed historical survey of the rise of the Colony, and another describing the growth of the shipbuilding and ship-repairing industries, which are of great importance to both the Royal Navy and the mercantile marine. Mention should be made, also, of the reminiscences of the Colony contributed by the veteran Sir Robert Ho Tung. We note that *The China Mail* itself has a history almost as long as that of the Colony, having been founded in 1845, and offer congratulations to our contemporary on their success in producing so comprehensive a number under war conditions.

PERSONAL.

MR. ROLLO S. BARRETT, F.S.I., sole partner in the firm of Messrs. William Armstrong and Sons, consulting mining engineers, has taken into partnership MR. EDRIC C. HAMILTON-RUSSELL, for some years joint general manager of Doncaster Amalgamated Collieries, Limited, and MR. E. TROTTER, chief surveyor to the firm for a number of years. For the duration of the war, the business is being carried on at Heddon Hall, Heddon-on-the-Wall, Newcastle-upon-Tyne.

MR. JOHN COOPER, A.M.Inst.T., has been selected to fill the newly-created position of deputy general manager of the Portsmouth Transport Department.

MR. R. C. REYNOLDS, O.B.E., has been appointed Board of Trade representative on the Area Board in the North-Western Region, in succession to SIR THOMAS BARLOW, K.B.E., who has been appointed Deputy Controller-General and Factory Controller of the Control of Factory and Storage Premises.

MR. N. RYLANCE, traffic superintendent of the Rotherham Corporation Transport Department, has been promoted to the position of chief assistant to the general manager of the undertaking.

MR. R. R. KENNAN, A.M.I.Mech.E., has left the service of Messrs. The Brush Electrical Engineering Company, Limited, Loughborough, to take up the position of sales manager to Messrs. Mono Pumps, Limited, Arnfield Works, Audenshaw, near Manchester.

The new London address of Messrs. HEPWORTH AND GRANDAGE, LIMITED, Bradford, is 4, Westbury-avenue, London, N.22. (Telephone Bowes Park 5447-8.)

MR. F. SAMUELSON, M.I.Mech.E., M.I.E.E., who has been a director of Messrs. The British Thomson-Houston Company, Limited, Rugby, since 1934, has retired after 44 years' service with the Company.

MR. JOHN THOMSON, M.B.E., M.Inst.C.E., has been elected chairman of the Scottish Branch of the Institution of Structural Engineers.

BOOKS RECEIVED.

United States Geological Survey. Bulletin No. 899-B. *Geologic Structure and Occurrence of Gas in Part of Southwestern New York.* Part 2. *Subsurface Structure in Part of Southwestern New York and Mode of Occurrence of Gas in the Medina Group.* By G. B. RICHARDSON. [Price 30 cents.] Bulletin No. 922-J. *Chromite Deposits in the Seiad Quadrangle, Siskiyou County, California.* By G. A. RYNEARSON and C. T. SMITH. [Price 30 cents.] Bulletin No. 922-O. *Chromite Deposits of the Pilliken Area, Eldorado County, California.* By F. G. WELLS, L. R. PAGE and H. L. JAMES. [Price 35 cents.] Bulletin No. 922-P. *Chromite Deposits in the Sourdough Area, Curry County, and the Briggs Creek Area, Josephine County, Oregon.* By F. G. WELLS, L. R. PAGE and H. L. JAMES. [Price 30 cents.] Washington: Superintendent of Documents.

United States National Bureau of Standards. Report BMS 64. *Building Materials and Structures. Solar Heating of Various Surfaces.* By H. V. COTTONY and R. S. DILL. Washington: Superintendent of Documents. [Price 10 cents.]

A Treatise on Surveying. Volume II. Compiled by R. E. MIDDLETON and the late OSBERT CHADWICK. Fifth edition. Revised by PROFESSOR M. T. M. ORMSBY. New York: Chemical Publishing Company, Incorporated. London: E. and F. N. Spon, Limited. [Price 12*s.* net.]

Barlow's Tables of Squares, Cubes, Square Roots, Cube Roots and Reciprocals of All Integer Numbers up to 12,500. Edited by DR. L. J. COMRIE. Fourth edition. New York: Chemical Publishing Company, Incorporated. London: E. and F. N. Spon, Limited. [Price 8*s.* 6*d.* net.]

United States Bureau of Mines. Technical Paper No. 615. *Splint Coals of the Appalachian Region: Their Occurrence, Petrography and Comparison of Chemical and Physical Properties with Associated Bright Coals.* By G. C. SPRUNK and others. [Price 10 cents.] Technical Paper No. 616. *Carbonizing Properties and Petrographic Composition of Lower Banner-Bed Coal from Keen Mountain Mine, Buchanan County, Va., and the Effect of Blending This Coal with Pittsburgh-Bed (Warden Mine) Coal.* By A. C. FIELDNER and others. [Price 10 cents.] Technical Paper No. 617. *Characteristics of Fuel Pitches and Their Explosibility in Pulverised Form.* By IRVING HARTMANN, H. C. HOWARTH and H. P. GREENWALD. [Price 10 cents.] Washington: Superintendent of Documents.

United States Coast and Geodetic Survey. Special Publication No. 222. *Triangulation in South Carolina* (1927 *Datum*). Part 3. *First- and Second-Order Triangulation and Traverse in the Northeastern Part of the State.* By H. P. KAUFMAN. Washington: Superintendent of Documents. [Price 30 cents.]

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—Conditions on the Welsh steam-coal market have displayed little variation during the past week. Operators, both in the home and foreign sections again experienced a brisk demand but little new business could be negotiated for early delivery. The outputs of the collieries normally catering for the home market, although steadily maintained at recent levels, were still insufficient to enable sellers to cover the requirements of buyers for early deliveries. There was a sustained demand for both stocking and industrial purposes. Exporters, although very favourably placed with orders, were unable to accept business where a definite delivery date was stipulated. Nevertheless, what supplies were thrown back on exporters' hands were provided with a ready outlet in the home section. The firmest section of the market continued to be presented by the bituminous small grades, the potential outputs of which were almost completely sold for a long time ahead. Best large coals were being steadily absorbed under existing contracts and prices were maintained, while offers of sized sorts were still only very sparingly made for future delivery. Dry small coals again attracted only a limited interest and with a plentiful supply available the tone remained dull. Cokes were still very busy, and new business was consequently not easily arranged. Patent fuel was quiet.

The Iron and Steel Trade.—Activities in the iron and steel and allied trades of South Wales and Monmouthshire were well maintained last week. Although various restrictions were making business in certain products difficult to negotiate, the demand was maintained and producers in other sections were working at full capacity in order to meet requirements.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The steel and engineering firms in this district will close down for two days this week-end to enable the necessary repairs to furnaces and machines to be carried out. Recent activity in the buying of all types of raw and semi-finished materials shows no signs of diminution. Inquiries at producing works indicate that the demand is expected to become more extensive. There is a heavy run on basic billets, and the call for steelmaking alloys, scrap, and other materials is at a high level. Orders are more numerous in the heavy machinery and engineering branches, and there is an active market in steelworks' and ironworks' machinery and related equipment. Heavy grinding and crushing machines are progressive lines. Developments in the Colonies and Dominions are calling for excavating and dredging machinery, and steel balls for crushing purposes are in strong request. Mining equipment is in good demand, and British collieries are buying more extensively. Activity is pronounced at works producing agricultural implements and machinery parts, and the present season has been the best for many years. Works specialising in machinery parts have satisfactory order books, most of the business being on inland account, though sales to the Colonies are good. Electrical-equipment makers are actively employed on home orders. Boiler makers are exceptionally busy, and producers of pumps and parts are operating at full capacity. Numerous fresh orders are coming to hand for excavating machinery, trench diggers, tractors, and cement and concrete-mixing plant. The demand for high-efficiency steels is heavy, the output of stainless steel being exceptionally high. Tool-steel makers are producing record outputs, and the tool trades are well placed with orders. Among the lines in demand are twist drills, hacksaws and blades, and precision tools. Machine knives and tools are also active media.

South Yorkshire Coal Trade.—Collieries in this area are accounting for larger outputs. The demand for industrial fuel has been well maintained, and steam coal is a steady line. Smalls and slacks are in demand by power stations and gasworks. The house coal market is satisfactory and consignments to the South of England are larger than they have been for some time. All types of cokes are in strong demand. The export position shows little change.

THE COLLECTION OF SALVAGE.—On page 370, *ante*, we referred briefly to the salvage activities of local councils during February and stated that the preliminary figures for March indicated a further all-round improvement. The Ministry of Supply now informs us that the value of the total sales of salvage collected by local councils rose from 198,993*l.* in February to 226,606*l.* in March. The paper salvaged increased from 21,441 tons in February to 24,099 tons in March; similarly, the metals recovered rose from 19,307 tons to 22,109 tons, and bones from 834 tons to 981 tons.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—Although some general improvement in the state of the iron and allied trades can be reported, the tonnage available for ordinary commercial undertakings is still very limited. The May total output, supplemented by a steady flow of imports of many commodities from the United States and the Dominions, covers the actual requirements for war purposes and it is hoped that material for industrial purposes will be released in increasing quantities.

Cleveland Iron Trade.—The make of Cleveland pig is still light and intermittent, and there is little likelihood of a resumption of the regular output so long as ample supplies of foundry iron are reaching North-East coast consumers from other producing areas. Adequate parcels of special quality iron for purposes particularly specified are coming to hand from various sources, but the bulk of the tonnage passing into use in the Tees-side zone is from the Midlands. The official quotations for Cleveland pig are ruled by No. 3 description at 128*s.*, delivered in the Middlesbrough district.

Basic Iron.—The output of basic iron covers the heavy requirements of the makers' own steel-producing plants, but provides no tonnage for the market. The nominal value remains at 120*s.* 6*d.*

Hematite.—The statistical state of the hematite branch of trade still necessitates rigid rationing and strict economy in use. Delivery licences are granted only to consumers unable to make use of any other iron. There is no prospect of an early addition to the limited make, but an improvement in the position in the near future is confidently expected to result from the increased imports of American hematite. The stabilised prices are based on No. 1 grade of iron at 138*s.* 6*d.*, delivered to North of England buyers.

Foreign Ore.—There is still difficulty in obtaining ores for making hematite iron, but other ores are plentiful. The free use of local and other native ironstone has greatly reduced the dependency on the supply of ores from abroad.

Blast-Furnace Coke.—Durham blast-furnace coke is plentiful and the consumption is heavy, but transactions are few, local users being as extensively bought as they consider desirable and sellers being disinclined to add to their heavy bookings until they have cleared off a number of running contracts. The recognised values are at the level of good medium qualities at 35*s.* 6*d.* f.o.r.

Manufactured Iron and Steel.—Semi-finished iron and steel users have considerable stocks of billets, blooms, etc., and are receiving good deliveries so that the re-rolling mills are likely to keep operating at about their maximum capacity. In the finished industries, all descriptions of constructional steel are in good demand, and the pressure for deliveries of shipbuilding requisites is unrelaxed. Sheet makers have more work on hand than they can deal with. Makers of special alloy steels are turning out heavy tonnages and manufacturers of railway material are readily disposing of their outputs. Soft-steel billets are quoted at 12*l.* 5*s.*; hard billets at 13*l.* 12*s.* 6*d.*; joists and sections at 15*l.* 8*s.*; heavy ship plates at 16*l.* 3*s.*; and heavy rails at 14*l.* 10*s.* 6*d.*

Scrap.—The exceptionally large supply of iron and steel scrap is still insufficient to meet the abnormally heavy demand fully. The demand is greatest for heavy grades of both iron and steel.

STIRRUP PUMP ATTACHMENT: ADDENDUM.—We have been informed by Messrs. Tangyes, Limited, Birmingham, the makers of the ingenious attachment for carrying stirrup pumps described on page 383, *ante*, that they have appointed Messrs. Brown Brothers, Limited, Dawlish-road, Selly Oak, Birmingham, 29, sole distributors for it throughout the British Isles. All correspondence on the subject should be addressed to this firm, and not to Messrs. Tangyes, Limited.

CANADIAN APPRECIATION OF THE LATE SIR J. J. THOMSON.—The March issue of the quarterly journal, *Revue Trimestrielle Canadienne*, published by the Association des Anciens Elèves de l'Ecole Polytechnique de Montréal, University of Montreal, contains a well written memoir of the late Sir J. J. Thomson, written by Dr. André V. Wendling and entitled "Le Découvreur du Corpuscule Electronique." The author, who is an old student of McGill University, recalls that several students of Sir Joseph, including Professors Callendar and Rutherford, have taught, and are teaching, physics at that University, and then proceeds to give an intimate account of the life and work of Sir Joseph, drawn for the most part from the utterances and writings of men who knew him well. He says of him that he was "le 'Mr. Chips' des physiciens Britanniques et le plus humain des universitaires."

NOTICE OF MEETING.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF ELECTRICAL ENGINEERS.—*Meter and Instrument Section:* Friday, June 6, 1 p.m., The Waldorf Hotel, Aldwych, W.C.2. Informal Luncheon.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—In the Scottish steel trade the heavy demands of the Government are accounting for the greater part of the present output, and there is difficulty in obtaining any steel material for general commercial purposes. The shipbuilding firms are exceptionally busy, so that the consumption of plates and sections is on a large scale and plant at the steelworks is being kept running at full capacity. There is also a steady demand for plates from boilermakers, and for structural material from constructional engineers. Locomotive and wagon builders are exceedingly busy and are specifying freely for the necessary steel material. The supply of steel scrap is good, but more could be utilised by the steel makers. There is great activity in the black steel-sheet trade and makers are receiving urgent demands for deliveries against contracts. The following are the current quotations:—Boiler plates, 17*l.* 12*s.* 6*d.* per ton; ship plates, 16*l.* 3*s.* per ton; sections, 15*l.* 8*s.* per ton; medium plates, ¼ in. and thicker, rolled in sheet mills, 21*l.* 15*s.* per ton; black steel-sheets, No. 24 gauge, 22*l.* 15*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, 26*l.* 2*s.* 6*d.* per ton, all for home delivery.

Malleable-Iron Trade.—Satisfactory conditions continue to prevail in the malleable-iron trade of the West of Scotland and steady employment is general. The re-rollers of steel bars are not so busy and are able to give prompt delivery to any orders received. The stocks of semies now held are ample for all requirements. To-day's quotations are as follows:—Crown bars, 15*l.* 12*s.* 6*d.* per ton; No. 3 bars, 13*l.* 12*s.* 6*d.* per ton; No. 4 bars, 13*l.* 17*s.* 6*d.* per ton; and re-rolled steel bars, 17*l.* 15*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—During the past week there has been little change in the conditions ruling in the pig-iron trade of Scotland and a steady output has been maintained. Consumers' demands have been heavy and constant, and the whole production of hematite and basic iron is rapidly absorbed. The position with regard to foundry iron is much better and sales have increased. The raw material supply is satisfactory. The following are the present market quotations:—Hematite, 6*l.* 18*s.* 6*d.* per ton, and basic iron, 6*l.* 0*s.* 6*d.* per ton, both delivered at the steel works; foundry iron, No. 1, 6*l.* 5*s.* 6*d.* per ton, and No. 3, 6*l.* 3*s.* per ton, both on trucks at makers' yards.

THE UNITED STATES OIL INDUSTRY.—The output of crude oil in the United States, during the week ending April 26, averaged 3,726,850 barrels daily, against 3,752,650 barrels in the preceding week.

THE E. J. FOX GOLD MEDAL.—The Council of the Institute of British Foundrymen has accepted the recommendation of the assessors, Sir William J. Larke, K.B.E., and Dr. J. E. Hurst, to award the E. J. Fox Gold Medal for 1941 to Mr. Percy Pritchard, in recognition of the scientific and technical contributions which he has made to the development of the foundry industry, particularly in light aluminium and magnesium alloys. Mr. Pritchard is managing director of the Birmingham Aluminium Company, Limited, the Midland Motor Cylinder Company, Limited, and Messrs. Birmid Industries, Limited. The presentation will be made at the annual general meeting of the Institute, which is to be held at the Midland Hotel, Manchester, on Saturday, July 12.

THE NEWCOMEN SOCIETY.—The summer excursion of the Newcomen Society will, this year, take the form of a day's motor-coach outing, on Friday, June 13, to Amersham, Beaconsfield, Knotty Green, Penn, Nap Hill, Turville Heath, and Stokenchurch, where handicraft Windsor chair making, "bodger" chair-leg making, and chair manufacture on the small factory scale will be witnessed. The party will assemble at the Institution of Mechanical Engineers, Storey's-gate, London, S.W.1, at 9.50 a.m., the return to the same place being timed for 6.0 p.m. Members, who may bring guests, are asked to notify their intention to attend, to the joint honorary secretaries of the Society, 43, King's-road, Chelsea, London, S.W.3.

CURING PRESS FOR RUBBER CONVEYOR TUBING.

(*For Description see page* 437).

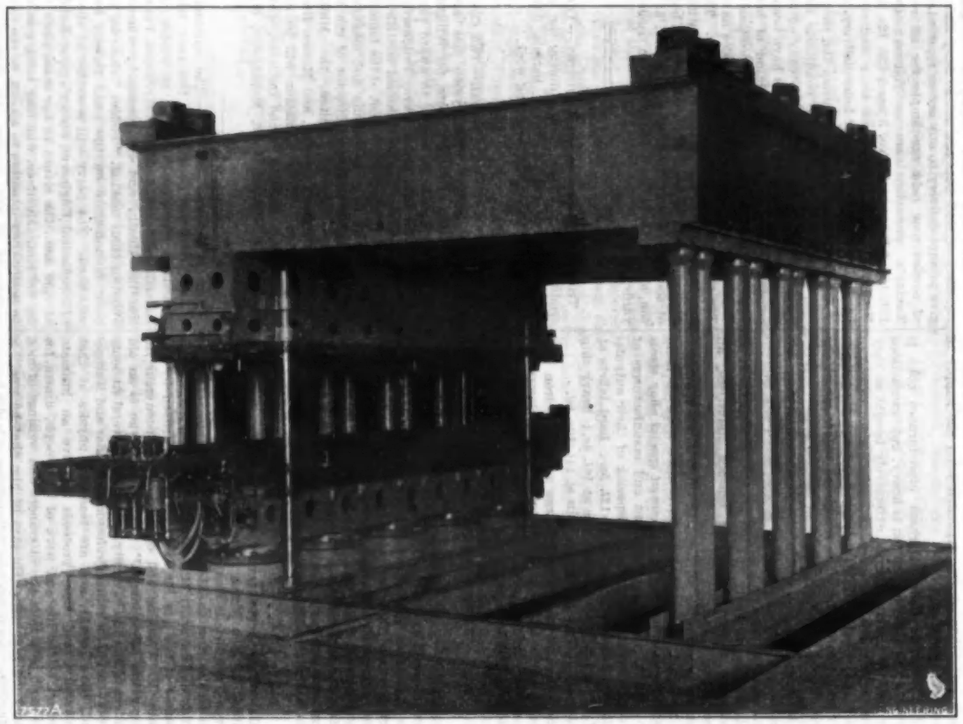


FIG. 1.

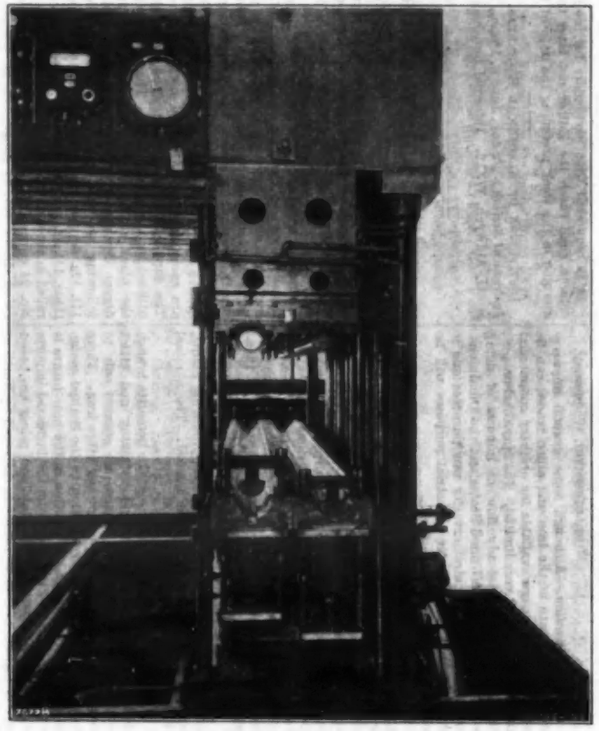


FIG. 2.

INSTITUTE OF METALS.

As already mentioned in our columns, the 31st annual May Lecture of the Institute of Metals was delivered on Wednesday, May 28, in the Clarendon Laboratory, Oxford, by Dr. F. Simon, F.R.S., reader in thermodynamics in the University of Oxford. Dr. Simon, who had chosen as his subject "The Significance of Low Temperature Research," stated that, at low temperatures, phenomena connected with small energy changes must be expected. In pre-quantum theory times no such changes could be expected and consequently the interest in the lower temperatures was mostly restricted to a mere "race" downwards. There was a change on the advent of the quantum theory, which showed that the vibrational quanta in condensed matter corresponded to this region of temperature. The consequent drop of the specific heat towards 0 deg. K., had a profound influence on all properties of matter, particularly through its connection with the third law of thermodynamics. This law and its implications for the theory and problems of technology were then discussed by the lecturer, together with its corollary, the unattainability of the absolute zero. It was then shown how every phenomenon occurring in any particular temperature region could be employed to reach this region. Consequently, stated the lecturer, the discovery of magnetic states of matter, with very small energy differences between them, had led to a new method for reaching temperatures still lower than had been possible with gas liquefaction. This new procedure was, in fact, Debye-Giauque's magnetic method. Much new information might be expected from investigations in this temperature region and in the still lower region which might be reached using the nuclear paramagnetism. There was a type of phenomenon, characteristic of the lowest temperatures, which could occur only in this region, namely, that region in which the zero-point energy was predominant, and, in this connection, the behaviour of liquid helium might be cited as an example. Finally, it appeared that the low-temperature region could be employed to obtain results from model experiments of great practical interest. In this manner, it was possible to investigate phenomena inaccessible to direct experiments at high temperatures because the requirements involved, such as pressure or magnetic field, were then prohibitive.

The lecture, it is of interest to note, was the first of the series to be given out of London, and prior to its delivery a brief general meeting of the Institute was held. In the course of this, the President, Lt.-Col. the Hon. R. M. Preston, D.S.O., presented the Institute's Platinum Medal, for 1941, to Dr. C. H. Desch, F.R.S., for his services to non-ferrous metallurgy. Since his retirement from the position of Superintendent of the Metallurgy Department of the National Physical Laboratory, in 1939, Dr. Desch has been adviser to the Iron and Steel Research Council. He is a past-President of the Institute of Metals and of the Faraday Society, and a vice-president and Bessemer Medallist of the Iron and Steel Institute. It may be recalled that the Institute of Metals medal, which is awarded annually without restrictions of race, creed or even membership of the Institute, has been offered to the Council, for award, by the Mond Nickel Company, Limited. It is of pure platinum, the medal having been prepared at the Company's refinery in London. The first recipient of the medal was Sir William H. Bragg, F.R.S., who received it in 1938. The second award was made in 1939, to the late Sir Harold Carpenter, F.R.S., who held the unique distinction of having been President of all three of the leading British metallurgical societies, namely, the Iron and Steel Institute, the Institution of Mining and Metallurgy and the Institute of Metals. The third award of the medal was made last year to the distinguished American metallurgist, Dr. P. D. Merica, the presentation being made, on behalf of the President of the Institute, at the British Embassy at Washington, by Viscount Halifax, the British Ambassador to the United States.

INSTITUTION OF STRUCTURAL ENGINEERS.—The Bronze Medal of the Institution of Structural Engineers, for the best paper read during the 1940-41 session, has been awarded to Mr. Leslie Turner, B.Sc., M.Inst.C.E., for his paper, "Examples of Modern Buildings."

ENGINEERING.

Offices for Publication and Advertisements, 35 & 36, Bedford Street, Strand, London W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS { "ENGINEERING," LESQUARE LONDON.

TELEPHONE NUMBER—TEMPLE BAR 3663 (2 lines).

SUBSCRIPTIONS, HOME AND FOREIGN.

"ENGINEERING" may be ordered from any newsagent in town and country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months (or for six or three months, *pro rata*), payable in advance :—

For the United Kingdom	£3 5 0
For Canada—	
Thin paper copies	£2 18 6
Thick paper copies	£3 3 0
For all other places abroad—	
Thin paper copies	£3 3 0
Thick paper copies	£3 7 6

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines, or under, and one shilling per line up to one inch. The line averages six words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns, of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

All accounts are payable to "ENGINEERING," Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

CONTENTS.

	PAGE
The Testing of Dust-Extraction Plant (*Illus.*)	421
Literature.—Works Organization and Management. Pumps	423
Vis-à-Vis Internal-Combustion Engines (*Illus.*)	423
The Use of Cast Iron in Building	425
Recent Applications of Fluid Couplings (*Illus.*)	426
The Butterley Standard Bridge (*Illus.*)	427
Institution Elections	428
Personal	428
Books Received	428
Notes from the South-West	429
Notes from South Yorkshire	429
Notes from Cleveland and the Northern Counties	429
Notice of Meeting	429
Notes from the North	429
Institute of Metals	430
H.M.S. Hood	431
The Co-ordination of Hand and Eye	432
Notes	433
Central Station for Industrial Steam Supply at Verviers, Belgium	433
Obituary.—Lord Austin of Longbridge (*with portrait*). Mr. T. L. Miller, O.B.E. Mr. E. O. Forster Brown. Mr. H. J. Eck. Mr. Joseph Cash	435
Letter to the Editor.—Calculation of Terminal Speeds	436
Travelling-Pipe Conveyor (*Illus.*)	437
Labour Notes	438
Condensing Plant and Cooling Water Systems (*Illus.*)	438
Catalogues	440
"ENGINEERING" Patent Record (*Illus.*)	440

One-Page Plate.—TRAVELLING-PIPE CONVEYOR.

ENGINEERING

FRIDAY, MAY 30, 1941.

VOL. 151. No. 3933.

H.M.S. HOOD.

THE loss of the battle cruiser Hood on Saturday last, in an action between Greenland and Iceland with the German battleship Bismarck and the cruiser Prinz Eugen, has brought the "Battle of the Atlantic" into a new and tragic prominence. The details that are available as we write are still incomplete, and it may well be that the full story and its probable lessons for naval designers may not be pieced together for some time, even by those most directly concerned to prevent its repetition; but the reception of the first Admiralty communiqué at home and overseas, and especially in the United States, showed how deeply public feeling was moved by the catastrophic end of this fine ship and practically her entire complement. The sinking of the Bismarck herself only three days later brought a correspondingly widespread satisfaction that they had not fought in vain. The largest warship in the world, and unquestionably the handsomest that has been built since steam and armour metamorphosed the whole architecture of fighting ships, the Hood may be regarded as the apotheosis of the battle cruiser as a distinct type. It is a grim but striking coincidence that, bearing the famous name of the admiral whose flag flew at Jutland in the Invincible —"the mother of all battle cruisers," as Sir Julian Corbett termed her—she should have met so exactly similar a fate. The temptingly dramatic parallel which comes instinctively to mind is that of the old boxer unable to withstand the young, but to accept it as a true analogy would be a misreading of the facts; the Invincible was only six years older than the Derfflinger, the ship that was mainly responsible for her destruction, and was similarly armed, though not so well armoured; and the Hood, though a clear 20 years older than the Bismarck in point of time, carried a closely comparable armament and was one of the most heavily armoured vessels in the Royal Navy. Within the past 12 years she had undergone two major refits, one of which, at least, involved considerable reconstruction to keep her abreast of modern requirements.

As was indicated by Sir Eustace d'Eyncourt in his paper on the ship, delivered at the spring meeting of the Institution of Naval Architects in 1920,* the disposition of the armour was such as to give unusually good protection against plunging fire of the kind that sank the Indefatigable and the Queen Mary, both of which received their fatal hits at ranges of about 16,000 yards. In all, the armour and other protection of the Hood amounted to nearly 14,000 tons. The Invincible was hit by the Derfflinger at not more than 10,000 yards ("below 9,000," according to the *Official History of the War*) at either of which ranges, obviously, the trajectory is much flatter and the possibility of penetrating vertical armour is correspondingly increased. It is remarkable in the extreme that so much more heavily protected a ship should have been destroyed in similar fashion at a range of 23,000 yards—greater by a full mile than any recorded at Jutland. It is premature, however, to assume that a hit on a turret alone was responsible, and that all the elaborate precautions taken to prevent cordite charges in the hoists from lighting back in succession, so exploding the magazine, have proved to be completely futile.

No details are available regarding the armour and subdivision of the Bismarck class, but it is safe to conclude that it is designed on the generous lines traditionally adopted by the Germans in battleships, the type to which this ship and her sister, the Tirpitz, officially belong. Apart from this official designation, however, and the difference in overall length, there is not a great deal to distinguish the general design from that of a battle cruiser, as represented by the Hood. Comparison of their main particulars shows that in speed, armament and protection, the inevitable tendency of the two types to coalesce has progressed so far that it may be said, for all practical purposes, that they have become one, which is a battleship and not a battle cruiser any longer. The Hood had a displacement of 42,000 tons; eight 15-in. and twelve 5·5-in. guns; a speed of about 31 knots; and 12-in. armour on the broadside, and on the turret sides and the barbettes (15-in. on the turret faces). According to *Jane's Fighting Ships*, the Bismarck and Tirpitz displace 35,000 tons, carry eight 15-in. and twelve 5·9-in. guns, and have a designed speed of "probably 30 kts."—which is near enough to that of the Hood to constitute no real difference. The Hood measured 860 ft. overall, by 105 ft. beam and 26 ft. mean draught; and the Bismarck class, according to the same authority, are 729 ft. long on the water line, 118 ft. beam, and 26 ft. mean draught. Allowing for the probability that the machinery weight of the more modern ship is less than that of the older vessel for the respective powers developed, it is unlikely that the armour of the German ships is on a much more generous scale than that of the Hood, although it may be differently disposed. In short, although the Hood was built as a battle cruiser and possessed at that time the distinguishing characteristics of the type, by the end of her career she had become a battleship —not merely in effect, but in fact—with almost all the characteristics of that type; in its rapid evolution, the battleship has overtaken and absorbed the battle cruiser, the main function of which has now passed to the torpedo-carrying bomber.

This process of evolution and then devolution of the battle cruiser, all in the period of little more than 30 years, must be of particular interest to the veteran Professor William Hovgaard, who, for many years, occupied the chair of naval design and construction at the Massachusetts Institute of Technology and who appears to have been the first to draw public attention to the probable development of the "battleship-cruiser" as a separate type. He did so in a paper delivered in 1905 before the Society of Naval Architects and Marine Engineers, in New York, but subsequently expressed the view that his ideal type had been anticipated by Cuniberti's four ships of the Vittorio Emanuele class, designed for the Italian Navy in 1904 and completed in 1907-8; though this point, perhaps, is debatable in view of the mixed armament of these four ships. Undoubtedly, however, the tendency towards the battle cruiser was in the air at that period, and its introduction by one navy or another could not have been long delayed. The special Committee on

* See ENGINEERING, vol. 109, page 423 (1920); also illustrated description on page 397, in the same volume.

Designs, on whose recommendation the British Admiralty decided to build the Invincible, Inflexible and Indomitable, was appointed in 1904; and Japanese naval opinion was inclining in the same direction, as was shown by the increased speed given to the ships of the Tsukuba and Ibuki classes, laid down in 1905-7, by comparison with the general practice at that time. Although subsequently described as battle cruisers, these were really transition designs, like the Vittorio Emanuele; not at all comparable with the three Invincibles, which were definitely revolutionary in character.

Rather curiously, in view of the Japanese interest in the type, the United States naval authorities took no active steps for at least ten years to construct any battle cruisers; and it was not until 1916 that Congress authorised the building of the class of six ships to which the Lexington and Saratoga were originally intended to belong. Their design was so radically altered after the decision to complete them as aircraft-carriers that the original intention may be said hardly to have progressed beyond the paper stage; but there has always been a considerable feeling among American students of naval policy that the lack of such ships constituted a serious weakness, and this view was forcibly expressed by Commander H. E. Rossell (CC), U.S.N., in a paper abstracted on page 74 of our 139th volume (1935).

Speaking in the discussion on Commander Rossell's paper, Professor Hovgaard recalled his own early advocacy of the type, but declared that nowhere had its ideal development been attained, although he admitted that it had been closely approached in the Hood, some of the German ships, and in the later Japanese designs. He urged particularly the need that the United States should possess such vessels, capable of undertaking strategic reconnaissances in force at great distances; especially in view of the absence of the advanced bases necessary to support the operations of a battle fleet. A squadron of battle cruisers, however, with a screening and reconnoitring force of light cruisers, destroyers and aircraft carriers, would form a strategic unit "comparable to the queen on a chessboard." This was not to suggest, Professor Hovgaard added, that battleships were unimportant; but meant that a considerable fraction of the battleship fleet should be endowed with higher speed.

Already, however, the tendency was evident to give all battleships higher speed; and the technical problems, as well as the cost, involved in maintaining the previous ratio between the speeds of the two types, threatened to outweigh any advantages that could be reasonably expected. Commander Rossell had suggested that a margin of 20 per cent. over the speed of the contemporary battleship was sufficient for a battle cruiser; but, with battleship speeds becoming more or less standardised at 30 knots, battle cruisers would have to be capable of 36 knots at the least. This is not technically impossible, perhaps, but must be regarded as impracticable, if only on the score of the increase in dimensions that would be necessary. The fact that the screening and scouting craft intended to work in company also would have to be capable of that speed introduces further complications.

In the circumstances, it is hardly to be expected that any more battle cruisers will be built; at all events, none with the hybrid characteristics that have marked the majority of the vessels so designated. There is the possibility that some of the 40,000-ton ships building or projected for the larger navies may be, in effect, improved Hoods; but the common policy of concentrating on the provision of a very heavy main armament makes such a course improbable, unless some great fleet action still to come demonstrates beyond question that three-gun and four-gun turrets are a mistake. There now remain of the British battle cruisers only the Repulse and Renown. Both are powerful ships, but after the experience of the Hood they cannot be regarded as arguments for a continuance of their class, however brilliantly they may perform in action. As a type, the battle cruiser may be considered as dead, but it has died gallantly; to quote Corbett again, "in the highest exultation of battle, gilding with new lustre the immortal name of Hood."

THE CO-ORDINATION OF HAND AND EYE.

AT all times in the history of mankind, the duration of the reaction time between some signal conveyed to the brain by the eye, or ear, and the muscular response by which it is met, has been an important factor in bringing about success or failure. This, indeed, applies to the whole animal world and may well be a significant influence in the process of natural selection by which one type of organism ousts another. In primitive man, a short reaction period would frequently determine survival in face of physical danger, and would still more frequently form a measure of the success of the hunting by which he lived. In normal civilised life, numerous safeguards have been provided by which the citizen is shielded, despite himself, from many of the hazards of an earlier age, and although quick response to an external stimulus may still avert danger, it is more usually of importance as an element in success.

The complexity of modern life has added enormously to the number of occasions in which rapid reaction is important. Some, as for instance, those which arise in the driving of a car, or in the cricket field, are matters of common knowledge and discussion, but these favourite examples are but a small sample of a range which covers much of life and almost the whole of industry. The operation of a capstan lathe demands reaction to certain events visible to the eye, and the more rapid the reaction, the better the output of the machine. In many cases the stimulus is always the same, as, for example, that which is conveyed to a car driver by the traffic lights, and the reaction becomes unconscious. This applies to a large proportion of industrial operations. Even with practice, however, not all machine operators have the same reaction time, and one qualification of the more successful is capability of almost instantaneous response.

This matter of the co-ordination between hand and eye is one to which the National Institute of Industrial Psychology, and others, have given some attention. Various tests have been devised for the purpose of evaluating the qualifications of recruits to industry in order to determine their suitability for particular types of operation. These tests, in general, give some measure of intelligence, perseverance, and manual dexterity, but do not make any attempt to measure the actual time of manual reaction to a visual stimulus. As this time is a fraction of a second, its measurement is a physical problem of some nicety, and the wooden models, coloured balls, etc., with which such tests are frequently conducted, are entirely inapplicable.

In a paper by Messrs. R. C. Woods and A. S. MacDonald, of Ericsson Telephones, Limited, which appears in the May issue of the *Journal of the Institution of Electrical Engineers*, a description is given of apparatus and tests by which the actual time absorbed in observing a visual signal, and converting it into a manual movement, was measured. A second test is also described by which the co-ordination between manual responses and visual stimuli was determined. The first test covered time of response, the second, its accuracy. It is stated by the authors that the tests were devised owing to the fact that it had been decided to adopt machine accounting in a large works, mainly engaged on telephone and other light electrical work involving great numbers of components, and demanding quick and accurate cost control. The accounting machines were to be operated by girls, and as it was known that the normal learning period was three months, it was decided that preliminary tests would be of value if they would eliminate unsuitable candidates from the start, and so save the firm the expense of training girls who were ultimately to prove inapt at the work. Early elimination would also prevent disappointment in candidates who, with goodwill, had spent three months trying to learn an occupation for which they were constitutionally unfitted.

A large part of an accounting-machine operator's duty is to translate written information into the depression of appropriate keys on a keyboard, which, for good performance, requires both quick and accurate response. As already indicated, the measurement of these two qualities was carried out independently. For the reaction-time test, two small lamps, one red and one white, were placed before the candidates, together with a press-key. The lamps were lit ten times in a pre-determined irregular sequence and at irregular intervals. Depression of the key extinguished one of the lamps and the candidate was required to carry out this operation every time the chosen lamp was lit. The other lamp was to be ignored. It was introduced to form an element of distraction, thus making the test some measure of the candidate's power of concentration. The control and measuring equipment was placed at a distance from the lamps and key, so that the sound of the switches and relays should neither assist nor disturb the operator.

The paper gives a distribution curve, showing the results of the tests and connecting the time of reaction with the percentage of cases tested. Unfortunately, it does not state on how many returns the curve is based. The modal score, obtained by about 40 per cent. of the candidates, was 325 milli-seconds, the curve reaching from something above 400 milli-seconds to a little below 200. The percentages for the highest and lowest times was about four. As a check on the test, and on the candidates as a whole, a number of persons outside the group, including members of the laboratory staff, was also tested. The results obtained were within the same range, and it appeared that an average time of reaction of 200 milli-seconds was approaching the upper limit. When a good score was obtained, the individual reaction times closely approached the average of the ten, but poor scores usually consisted of more erratic individual times. When the paper was written, the results of these tests could not be co-ordinated with actual work on the accounting machines, but clearly, if it can be established that a good average performance, in the neighbourhood of the modal score of 325 milli-seconds, is associated with satisfactory machine operation, the test will form a valuable aid in the selection of staff.

For the test to determine the accuracy of manual response to visual stimuli, the candidate was faced with four coloured lamps irregularly spaced, so that the eye had to move a little up and down and sideways to look at each, and four press-keys arranged side by side on a small keyboard. The lamps were respectively orange, red, white and green, and one key was connected with each lamp. The lamps were lit in a predetermined irregular sequence which repeated only after 100 signals, and the candidate was required to depress momentarily the key associated with the lamp that was lit. This extinguished it, and when the key was released the next lamp in the cycle lighted. The test of a candidate started at any point in the cycle. Two meters were connected to the apparatus; one recorded the number of times the correct key was depressed in response to a signal and the other, the total number of operations in a test. After some experience, it was found satisfactory to arrange that the test of a candidate should cover three periods of operation, each of one minute. A rest pause was allowed between the runs.

The distribution curve illustrating the results of these tests shows a modal score of 44 correct operations per minute for some 28 per cent. of the cases tested. This score does not lie midway in the curve, but is nearer to the lower range. The best results shown were some 68 operations per minute for about 3 per cent. of the candidates, and less than 30 for a similar percentage. In view of the modal reaction time of 325 milli-seconds, and the possible 200, shown by the first type of test, it is clear that even the figure of 68 correct operations per minute need not be considered to be approaching the possible limit; with long experience, much better results might be expected. It seems a fair assumption, however, that candidates returning a score substantially below the modal are lacking in the natural ability necessary for carrying out the closely similar process which is required in the operation of the accounting machines and that those whose scores fall more than a little below the modal score may be considered unsuitable for proceeding with the necessary three months' training.

NOTES.

ABSENTEEISM.

THE proceedings of the Select Committee on National Expenditure range over so extended a field that it is sometimes difficult to believe that the complications of every matter that they investigate can have been probed to the final details. Perusal of their Fifteenth Report, however, which deals with labour in the aircraft industry, leaves no doubt that they are on safe ground in stressing the serious nature of the problem presented by absenteeism in the factories. It may be taken as certain that the importance of this matter is as fully appreciated by the managements as it is by the Committee. As their principal recommendation to deal with it, they urge that Sunday work in the shops should be discontinued, except for maintenance, repairs to plant, and similar essential purposes; and express the opinion that the general direction to aircraft firms, to work a seven-day week over long periods, has disturbed organisation and increased costs. The Committee do not subscribe to the view, rather widely held, that excessive wages are being paid in the aircraft industry, observing that the average wages of the highest-grade labour in typical factories does not exceed 7*l.* a week. Incidentally, this is no more than was paid to some girls on repetition shell operations during the last war. It is recognised, however, that such a wage (which is high, though not excessive) does offer a temptation to take an occasional day off; especially as the loss of earnings that it represents can be so easily made good by working for double wages on the following Sunday. As it would not be practical politics to do away with double-time payments for Sunday work, the only practical remedy, apart from appeals to the employees, is to reduce the Sunday work as much as possible. Obviously, the problem calls for a careful balancing of loss against gain. If, even with the difficulties introduced by absenteeism, a greater aggregate output can be maintained by working a seven-day week, present conditions demand that Sunday labour should continue; but, if careful investigation shows that an equal or better output could be obtained with shorter hours of work, that procedure should obviously be adopted. Perhaps, if more discretion were left to individual managements and a less rigid control were exercised by the Ministry of Aircraft Production, some of the labour difficulties such as these might be dealt with more easily. Other points in the report are suggestions that the Ministry of Aircraft Production should require all firms working for them to institute a system of waiting cards or some other method of ascertaining the true extent of idle labour; that the Ministry should take steps to ensure that firms observe the district wage rates and do not compete with their neighbours by increasing their bonus rates; and that more and better publicity should be organised, to indicate to women in particular the kind of factory work for which they are needed, and to remove incorrect impressions of its character which may be deterring suitable women from volunteering their services.

THE GENERAL COUNCIL OF BRITISH SHIPPING.

In a leading article on "Shipping and Transport," on page 372, *ante*, we referred to the establishment of a General Council of British Shipping, designed to be representative of both the Chamber of Shipping and the Liverpool Steam Ship Owners' Association, and of the various other sections of the industry. The composition of this new General Council has now been announced, and is as follows. Liners: Lord Rotherwick, Lord Essendon (alternate, Mr. W. C. Warwick), Sir Alan Anderson, G.B.E., Sir William C. Currie, Mr. J. R. Hobhouse, Mr. H. S. Holden (alternate, Mr. A. F. Hull), Mr. J. W. Booth, Colonel Denis Bates and Mr. A. Harold Bibby, D.S.O. Tramps: Sir Philip Haldin (alternate, Mr. F. J. Harrison), Mr. Philip Runciman, Mr. James Shearer, O.B.E. (alternate, Mr. Hugh Hogarth), Mr. W. A. Souter (alternate, Mr. Leslie Mann), Sir Willie Reardon Smith, Bart. (alternate, Mr. H. C. Bolter) and Mr. R. D. Ropner. Coasting liners: Mr. R. Kelso (alternate, Mr. Percy Wharton). Coasting tramps: Mr. Kenneth R. Pelly (alternate, Mr. C. E. Bell). Intermediate tramps: Mr. J. C. Radcliffe. Tankers: Mr. H. T. Schierwater and Mr. Stewart L. Browne. Small tankers: Mr. W. J. Everard. Near-trade liners: Mr. W. MacGillivray. The joint secretaries of the General Council are Mr. P. Maurice Hill and Mr. Martin Hill, and the offices are at 3 to 6, Bury-court, St. Mary Axe, London, E.C.3. It is emphasised in the announcement that the General Council will not be concerned with questions of personnel, which will continue to be dealt with by the Shipping Federation and the Employers' Association of the Port of Liverpool.

ELECTRIC-POWER REQUIREMENTS IN THE UNITED STATES.

The national defence programme which has been adopted in the United States, and which is constantly being extended, will necessitate a considerable increase in the supply of electric power. During the great war effort made in that country in 1918, the question of adequate power supplies was a matter for considerable anxiety at times, and it is clearly of the first importance that present plans should not be hampered by any shortage of generating capacity in important manufacturing areas. A report, forecasting probable electric-power requirements in 1942, has been issued by the Federal Power Commission, and is summarised in the April issue of *Electrical Engineering*, which forms the transactions of the American Institute of Electrical Engineers. The report states that, in approximately half of the power supply areas, the plant installed, or scheduled for coming into early operation, should be sufficient to supply the anticipated demand this year. In other areas, conditions can only be met by drawing on reserves or by inter-connection with other districts in which more adequate supplies are available. In view of the conditions which may arise in 1942, the necessity for continued attention to the whole question is emphasised. The demand for power is growing more rapidly than was expected. Consumption in December, 1940, exceeded that of September, 1940, by 2,609,154 kW, an increase 22 per cent. greater than the estimate made in September. In New England, New York, Philadelphia, New Jersey, Western Pennsylvania, Ohio, Michigan, Alabama and Georgia, North-Central Texas, and the Bonneville-Grand Coulee area, consumption exceeded the estimate by 53 per cent. New plant ordered between September and December, 1940, will increase installed capacity by 906,500 kW in December, 1942, but the report considers that a further 800,000 kW should be provided to come into operation late in 1942. The present planned increases fall short of probable demands, notably in up-State New York and the Georgia-Alabama area. In New York, considerable relief would be obtained by the provision of increased transmission capacity connecting the up-State area and the metropolitan systems.

BEYER-GARRATT LOCOMOTIVES.

In his speech at the annual general meeting of Messrs. Beyer, Peacock and Company, on May 20, the chairman, Captain Hugh Vivian, M.I.Mech.E., gave some particulars of recent Beyer-Garratt locomotives. In 1939, the company supplied six 4-8-4 + 4-8-4 locomotives of this type to the Kenya and Uganda Railway. These, which were the largest metre-gauge locomotives in the world, were followed by six additional similar engines in 1940. The Garratt design has now been further developed and the company, despite difficult war-time conditions of working, has produced a new model with a 4-6-4 + 4-6-4 wheel arrangement. Four locomotives of this type were shipped to South Africa in 1940, and are being employed on passenger and goods service between Bulawayo and Salisbury. The engines, which operate on a light 3-ft. 6-in. gauge line, are the largest locomotives in the world running on 60-lb. rails. On heavily-graded sections of the line, they haul passenger loads of 500 tons and goods-train loads of 1,050 tons. They are capable of maintaining speeds up to 60 miles an hour and are stated to have shown excellent efficiency from the points of view of coal consumption and maintenance. The engines have already completed 250,000 miles of running.

CENTRAL STATION FOR INDUSTRIAL STEAM SUPPLY AT VERVIERS, BELGIUM.

SYSTEMS in which a supply of steam is furnished to a number of consumers from a central station are in operation in various parts of the world. Usually, the distributing network of steam-pipes is laid in the roadways and the service is utilised for space heating. A pioneer installation of this class was constructed at Lockport, in the State of New York, nearly 60 years ago, and in North America there are now some 165 heat-distribution systems in operation, with a total length of distributing pipework of nearly 900 miles. Of these installations, 22 have outputs of over half-a-million tons of steam a year. This figure corresponds, approximately, to the total consumption of industrial steam in Verviers, in Belgium, which is situated 12 miles to the east of Liége, and is a centre of the woollen industry. In Europe, there are some 60 heat-distribution systems in operation, with a total length of pipe network of about 190 miles. Some of the more important are in Copenhagen, Berlin, Leipzig, Hamburg, Paris, and Brno in Czechoslovakia. As stated in our leading article on page 71, *ante*, there are similar systems in operation in Dundee and Manchester, but, as emphasised in that article, the matter has received little attention in Great Britain.

Many of the installations on the Continent cover a comparatively restricted area and supply heat to blocks of flats, or groups of public buildings. A detailed description of an example of this class, in Zürich, appeared in our columns some five years ago.* In that case, heat is supplied to a number of buildings grouped round, and associated with, the Technical College. The problems involved in the design of a system of this class, however, have much in common with those which present themselves in the case of a general town service.

It is frequently suggested that the combination of heat and electricity supplies from a common station should form a satisfactory arrangement, but actually this has been adopted only to a small extent. In the early days, when most electric power stations supplied direct current over comparatively small areas, the addition of steam supply to the electrical service might possibly have been a satisfactory arrangement, but arguments in favour of it have been greatly weakened by the introduction of high-tension distribution, with which the possible area of steam-supply could form only a small part of the area covered by the electric service. Although not unknown in North America, the combined supply is exceptional. When heat is distributed mainly to blocks of flats and offices, climate becomes of great importance, as it determines the number of hours of radiator-utilisation per year, which reacts directly on the permissible capital charges for the central station and the distributing pipework. This climatic factor is one of the main reasons why heat-distribution stations have been developed so extensively in North America, the long and severe winters making the service economically practicable. For the same reason, most of the installations in Europe are to be found in those countries which experience cold winters.

There is usually some good reason why a particular industry has been located where it is. The original location of many industries was largely determined by the existence of water power and although the coming of the steam engine, and later of the oil engine and electricity supply, enormously extended the possible location of factories, there are still many factors which tend to keep a particular industry to some specific area. The wool industry is a case in point. In the early days of the development of the factory system, when communication was difficult, wool manufacturers were attracted to districts near sheep-grazing country where, not only was low-head water power available, but there was also ample water for the industrial processes involved. These conditions led to the establishment of woollen mills on the edge of the Cotswolds, in the Yorkshire dales and in the Border Country, and

* ENGINEERING, vol. 141, pages 219 and 275 (1936).

the same considerations applied in Belgium, with the result that the wool industry became established in and around Verviers.

In the textile industries generally, the large quantities of low-grade process steam which are required have tended to prove an obstacle to the development of central electricity supply for motive power. As it is necessary to keep boilers in operation for the supply of the process steam, it is natural to use them also for electricity generation, the process steam being supplied through back-pressure engines or turbines. As pass-out turbines can now be obtained in quite small sizes, the position in some areas has become a matter for serious consideration by electricity-supply authorities. This condition was tending to arise in Verviers, where many of the manufacturers were installing, or considering the installation of, back-pressure plant and consequently ceasing to take a supply of current from the mains. In these circumstances the Société Intercommunale Belge d'Electricité decided that the best method of dealing with the situation would be to establish a low-pressure process-steam service for the mills, so that individual boiler plants could be eliminated and electric power taken from the town mains. As a result, the organisation known as L'Intervapeur Verviétoise was formed.

It was in the year 1935 that the power company began to make detailed investigations into the question of the supply of steam for the washing, dressing and dyeing of the wool, and also for heating and air conditioning, in the Verviers mills. It was found that a load of about 200 tons of steam an hour might be anticipated, with an annual consumption of half a million tons. The total length of supply main required was estimated at 15 km. By August, 1936, contracts having been made with a sufficient number of consumers, and the necessary agreements having been established with Government and local authorities, the work was put in hand. For the estimation of the probable consumption, consultation was made with and data obtained from, heat-supply companies and organisations in various countries. As a result, it was also possible to satisfy the municipal authorities of Verviers that the laying and maintenance of steam mains in the streets would not constitute a danger either to the public, or to the gas, water, electricity, drainage, telegraph and telephone services.

It is clear that, in deciding on the temperature and pressure for a steam-distribution system, the requirements and load curves of the consumers, and the location of their premises in relation to the central station, are matters of importance. Industrial buildings in Belgium are usually only of one or two storeys and the supply of steam to a structure of this type demands a type of distributing main different from that which may be suitable for supplying the very tall office blocks which are common in America. The question turns on the permissible capital cost of the mains per ton of steam delivered. The total load, and particularly the distance to which heat is to be transmitted, affect the choice, which lies between low-pressure water, at, say, 80 deg. to 90 deg. C., high-pressure water at 150 deg. to 200 deg. C., or steam at 30 lb. to 300 lb. per square inch. The manner in which the heat is to be utilised by consumers also affects this choice. As with electricity supply, the distance to which distribution can be carried out is an economic rather than a technical question. It is certainly possible, given an adequate load to cover the capital cost, to distribute to distances up to 15 km.

The heat loss from the mains depends on the type of insulation used, the pipe diameter, the nature of the fluid transmitted and the arrangement of the pipe supports. In practice, these losses are of the order of one calorie per hour per square metre of pipe surface per deg. C. difference of temperature between the fluid and the atmosphere. When steam is employed, it is necessary to allow also for the loss of heat in the condensate drained off by the steam traps. This may amount to from 20 per cent. to 40 per cent. of the radiation losses. In practice, the total loss varies between 10 per cent. and 40 per cent. of the heat delivered. A drop in pressure in the mains constitutes a loss, generally speaking, only when the network is supplied by the exhaust steam from prime movers. In that case, the pressure at the engine exhaust is equal to the pressure at the distant end of the distributing main, plus the drop of pressure in the pipes. The higher this total figure, the greater the back pressure at the prime movers and consequently the lower the power output. When the network is supplied with live steam, pressure drop does not involve a loss of energy in this way, and if considerable pressure drop is allowed for in the layout, the diameter of the pipes may be reduced and their radiation losses reduced correspondingly.

Some of the earlier heat-distribution installations were constructed with mains of large diameter, and consequently high capital cost, with the object of making them suitable for operation in conjunction with back-pressure steam plants. The desirability of following this lead was carefully investigated by Dr. A. de Smaele, the chief engineer of L'Intervapeur Verviétoise, before the installation was constructed. Theoretical arguments, based on thermodynamic considerations, presented an attractive case for the adoption of back-pressure working. They showed that it was theoretically possible with prime movers requiring 1,500 calories per kilowatt-hour produced, to supply 10 kg. of exhaust steam to the network for each kilowatt-hour of energy delivered. In the case of the Verviers installation, with a total supply of 400,000 tons to 500,000 tons of steam a year to the network, some 40 million to 50 million kWh per annum would be provided by the steam plant. Taking the cost of coal at 15 Belgian francs per million calories, the installation would show a saving of some 1·5 to 2 million francs per annum as compared with supplying the main directly with live steam.

This possible economy was obviously an important one, but before proceeding further it was necessary to investigate the cost of obtaining it. It would have involved the installation of boilers operating at 100 kg. to 120 kg. per square centimetre (1,420 lb. to 1,700 lb. per square inch); of turbines capable of operating either as back-pressure or condensing machines, in order to provide for the maintenance of the electricity supply at times when the demands on the distribution network were low; and of auxiliaries of special type suitable for operation at high pressure and temperature. It would also have required a skilled staff capable of running and maintaining an extra-high pressure plant. In view of the much heavier capital cost involved, and the added difficulties of operation, it was clear that the theoretical economies were not likely to be achieved in practice.

As a result of this general examination of the problem, it was decided to construct a central station at Verviers designed solely for the purpose of supplying heating steam. The station is situated alongside the main-line railway from Liége to Aix-la-Chapelle, and in a position not far from the "centre of gravity" of the load. A simple and straightforward layout was adopted in order to facilitate operation, and the steam generating units are independent of each other, in order to secure continuity of supply. Storage bins, four for coal and two for ashes, are situated alongside the railway, there being a double-track siding between these and the station. On the station side of the siding there are eight service coal hoppers. The coal bins, which have a capacity of 10,000 tons, are spanned by a travelling gantry, and a similar gantry spans the railway siding. Each carries a grab, and these can be locked together to operate as one. By means of this arrangement coal may be lifted from railway wagons and delivered either to the storage bins or to the service hoppers. Coal may also be lifted from any bin and delivered to any hopper.

The boiler house contains four three-drum boilers, each with a heating surface of 1,000 sq. m. and a normal capacity of 50 tons of steam an hour. They operate at a pressure of 25 kg. per square centimetre (355 lb. per square inch), and are fitted with superheaters which raise the temperature of the steam to from 200 deg. to 250 deg. C. The temperature may be regulated to suit the conditions of the steam demand. Pulverised-coal firing is employed, each boiler being provided with two pulverisers located below the service hoppers. A fan, situated alongside each pulveriser, delivers the fuel directly to the boiler combustion chamber which has a volume of 300 cub. m. There is a clinker breaker at the base of the ashpit, which has a rotating bottom as in a gas producer, the ash and ground clinker being delivered to a conveyor which transports them to bins situated near the coal bins. The coal burnt is relatively soft and has a sulphur content of 0·5 per cent. to 0·6 per cent.

The operation of the heat-supply system has resulted in the closing down of a large number of individual boiler installations. As a pure atmosphere is very desirable in the interests of the woollen industry, much attention has been paid to the cleaning of the flue gases from the power station. To eliminate dust from the flue gases, electric precipitators have been installed between the boilers and the chimney flue, and these are stated to trap 98 per cent. of the solid matter carried by the gases. The collected dust is led back to the boiler furnaces. The cleaned gases are finally discharged from a brick stack 100 m. high. The induced-draught fans, between the precipitators and the flue, are motor-driven through variable-speed hydraulic couplings, which give considerable flexibility in the boiler output.

To simplify operation, the station has been constructed without any basement, all motors and controls being situated at ground level. Auxiliary services are decentralised as much as possible; for instance, electricity supply for station purposes is obtained from four 1,000-kVA transformers feeding four 'bus-bar sections, one for each boiler unit. All motors are of the squirrel-cage type and all important circuit-breakers, which are of the air-break type, are located in the switch room. The motors are started and stopped by remote push-button controls. Any of the four boiler 'bus-bar sections, which operate at 500 volts, can be put in parallel with a fifth section, which supplies various general services. There are also 220-volt alternating-current 'bus-bars from which the circuits to the smaller motors are supplied, and a 110-volt direct-current service, operating in conjunction with an accumulator, for supplying the remote-control relays, the signal system and emergency lighting. The control room contains five panels, one carrying indicating instruments for each of the four boilers and a fifth fitted with gauges showing the steam pressures at the station and at the ends of the three primary distributing mains; the total quantity of steam being supplied to the mills is also shown. The installation has been made as simple as possible to operate; the recording instruments, showing steam pressure fluctuations, etc., are located in the boiler house, it being considered that the boiler attendants should be informed regarding load variations as well as of the magnitude of the load at any time. Coal and air for the boilers can be regulated by push buttons from the control room. A wide passage runs the whole length of the station, and in this are the two steam headers which are connected to the distributing mains at each end. The valves controlling the boiler connections are situated in this passage.

The question of an adequate feed-water supply to the station is obviously of great importance, as the condensate from the steam distributed is not recovered. Apart from other difficulties, this would be impossible for a large proportion of the supply, as the steam is mixed with other fluids for process work at the mills. Fortunately, an excellent supply was available from the Gileppe Reservoir, situated on the river of that name, some 10 miles to the east of Verviers. The Gileppe dam was constructed between 1867 and 1878 to provide a supply of soft water for the cloth factories of Verviers. The water contains only 25 mg. to 30 mg. of salts per litre, and the only treatment necessary is de-gassing. The plant installed reduces the oxygen content to less than 0·01 cc. per litre at a temperature of 40 deg. to 50 deg. C. The pumping plant supplying the stations consists of five centrifugal pumps, three with a capacity of 135 cub. m. per hour and two with a capacity of 40 cub. m. per hour. They can be driven either by steam turbines or electric motors.

The operating pressure chosen, 25 kg. per square

centimetre (355 lb. per square inch), was considered to be the highest for which riveted construction could be used. This policy avoided the necessity for special features in the boilers and pipe work and kept down the capital cost. The pressure required by the consumers was 7 kg. per square centimetre (100 lb. per square inch) and the dimensions of the distributing mains were chosen so that losses, maintenance charges, and interest on capital were reduced to a minimum. These considerations allowed the adoption of the comparatively small diameters of 250 mm. and 300 mm. for the principal distributing mains. The 250-mm. main has a total length of 4,800 m. and forms a loop system to the east of the station; the 300-mm. main runs in a westerly direction and has a length of 6,000 m. Service pipes to consumers have a total length of 2,000 m.

The mains are laid in covered-in concrete ducts constructed in the roadways. To obtain clear runs for the ducts, extensive diversions of water and gas mains, electric cables, etc., were necessary; the whole of this work was put in hand and completed before the trenches for the ducts were opened in the roadways. The mains are steel Mannesmann tubes, joined by welding. During this operation, a guard ring was placed inside the joint to prevent weld metal from entering the pipe. As the pipe network was comparatively rigid, it was necessary to introduce expansion joints at intervals. These are of the metal-bellows type, and allow for maximum movements varying from 25 mm. to 100 mm., depending on the location. The total expansion allowed for is 3 mm. per metre, and anchor points were chosen so that 100 mm. of expansion is provided for in each 30 m. of main. Between the anchors, the pipes are supported on rollers.

The question of insulation for the mains was investigated in considerable detail and many tests were made. It was necessary to consider the method of applying and securing the insulation, its durability, resistance to damp, coefficient of heat transmission, and cost. Finally, slag wool and spun glass were selected. The average thickness of insulating material used on the pipes is 140 mm. It is provided with an outer covering of bitumenised paper. Underground chambers, providing access to the mains, were constructed at convenient points on the route. In the parts of the main lying at a low level steam traps are fitted, and air-vent valves are provided in those at higher levels. The mains are sectionalised by means of valves.

It was considered desirable that constant and regular steam supplies should be furnished to customers whatever the demand, and that these should be metered exactly in the same way as an electricity supply. By means of reducing valves, the pressure of the steam delivered is kept constant to within plus or minus one-twentieth of an atmosphere, and the variable-orifice steam meters adopted proved very accurate. Each customer's installation consists of two valves, a steam filter, steam traps, and a safety valve. By opening a valve, the user is able to obtain a steam supply at any hour of the day or night.

In most cases, the cost to the manufacturer is less than that for which he could generate his own steam and, in any case, the operating convenience of the system is such that even an increased cost would be justified. A two-part tariff is in operation, based on the monthly consumption and the maximum demand, so that it is in the customer's interest to keep his requirements fairly constant. An analysis of individual load curves by the service department has enabled many customers to reduce their peak demand by introducing a regular regime in the starting up of steam-consuming plant. The installation of the central station has resulted in the closing down of a hundred separate boiler plants, operated by two hundred stokers, and frequently of low thermal efficiency; whereas the central station plant, of high efficiency, is operated by a total staff of 40.

In the preparation of this article, we have been indebted for much of the information to a paper read by Dr. A. de Smaele, technical director of the Société Intercommunale Belge d'Electricité, before the Belgian Society of Engineers.

OBITUARY.

LORD AUSTIN OF LONGBRIDGE.

THE news of the death of Lord Austin of Longbridge, K.B.E., LL.D., J.P., which occurred at his home, Lickey Grange, near Bromsgrove, Worcestershire, on May 23, will have been received with regret throughout the British Empire. He was well known as the founder and chairman of the Austin Motor Company, Limited, Longbridge Works, Northfield, Birmingham, and was the son of the late Mr. G. S. Austin, of Wentworth, Yorkshire. He was born on November 8, 1866, at Little Missenden, Buckinghamshire. Herbert Austin was educated at Rotherham Grammar School and at Brampton College, and, in 1884, went with one of his uncles to Australia. Soon after his arrival, he commenced his apprenticeship at Langland's Foundry, Melbourne, and later became associated with the Wolseley Sheep-Shearing Machine Company, Limited, eventually becoming manager. He returned to this country in 1893, to supervise the manufacture of his company's products, first at a small workshop in Broad-street, Birmingham, and subsequently in larger premises at Alma-street,

THE LATE LORD AUSTIN.

Aston, in the suburbs of Birmingham. As the demand for shearing machines was largely seasonal, the Wolseley Sheep-Shearing Machine Company turned its attention to other things, such as the manufacture of bicycle components and small machine parts.

About this time the motor road vehicle was being introduced, and Mr. Austin immediately saw the possibilities of this form of road transport. In 1895, he produced his first car—a three-wheeled vehicle—and this was soon followed by an improved model which was exhibited at the Crystal Palace. In 1901, he was elected a director of the Wolseley Sheep-Shearing Machine Company, becoming its chairman in 1911, and when the Wolseley Tool and Motor Car Company, Limited, was formed he was appointed general manager. With a strong desire to be entirely his own master, however, Mr. Austin founded the Austin Motor Company, Limited, in 1905, and secured a small vacant works at Longbridge, Northfield, which was then outside Birmingham. This factory occupied a site of 2½ acres and employed 270 workers; it produced 120 motor cars in 1906. During the war of 1914-18, the Longbridge works became a great centre for the production of munitions and millions of shells and great quantities of other war material were turned out. In recognition of his services to his country, Mr. Austin was created a K.B.E. in 1917. The period of reorganisation in the post-war years called for a great effort to face the prevailing industrial difficulties and to meet the ever-increasing competition in the motor-car industry. A period of intensive preparation resulted in the production of the popular little Austin "Seven" car, which was placed on the market in 1922. This was the first universally successful small car and earned for its originator the title of "Father of the Baby Car." Some indication of the position occupied by the Austin Motor Company is shown by the fact that just prior to the commencement of the present war the Longbridge Works occupied 220 acres, employed 16,600 workers, and produced 78,000 motor cars and commercial vehicles per annum. As is well known, Lord Austin took a leading part in co-ordinating the work of the shadow factories.

Sir Herbert was the recipient of many honours. He was created a Baron in 1936 and took the title of Lord Austin of Longbridge. In the following year the honorary degree of LL.D. was conferred upon him by the University of Birmingham. In 1937 he was appointed chairman of the Shadow Aero-Engine Committee, which position he relinquished in May, 1940. Lord Austin was elected a member of the Institution of Mechanical Engineers in 1918, and, in 1938, was made an honorary life member. In 1912, he was elected President of the Institute of British Carriage and Automobile Manufacturers; in 1931, President of the Institution of Automobile Engineers; in 1932, President of the Institution of Production Engineers; in 1934, President of the Society of Motor Manufacturers and Traders; and in 1939, President of the British Cast-Iron Research Association. Lord Austin's only son and heir was killed in action while serving with the Royal Artillery, in France, in 1915.

MR. T. L. MILLER, O.B.E.

MR. THOMAS LODWICK MILLER, whose death, we regret to have to record, took place at Heswall, Wirral, Cheshire, on May 21, was for nearly 50 years in private practice as a consulting mechanical and electrical engineer in Liverpool. He was born in 1860 and educated at Liverpool Institute and at the Liverpool School of Science. In 1875 he commenced an apprenticeship of five years in the Liverpool works of Messrs. Fawcett, Preston and Company, meanwhile continuing his technical education at Liverpool University College. After the conclusion of his pupilage in 1880 he remained with Messrs. Fawcett, Preston until 1888, when he was appointed lecturer in engineering at University College, Liverpool. In 1890, however, he resigned this appointment to open a private practice as a consulting engineer and thereafter was mainly engaged in advising local authorities on electric power, lighting and tramway schemes and in conducting arbitrations and giving evidence before Parliamentary Committees. He retired in 1938, and during his 48 years as a consultant carried out electric lighting and tramways schemes for the Bootle Corporation and lighting schemes for the Barnsley, Hoylake and West Kirby, Swinton, Pendleton, Atherton, Dundalk, Stretford and other electricity undertakings. He was also responsible for the design and lay-out of an electric lighting plant at Antofagasta, Chile, and electric power plants at Phurping Springs, Nepal, and at Hong Kong, for the Taikoo Dockyard, and for an adjacent sugar refinery, the design and construction of which he supervised.

In June, 1915, Mr. Miller was appointed secretary of the Liverpool Munitions of War Committee, and, two years later, was made general manager and secretary. In this capacity he had charge of six National Factories, and controlled the products of 80 contractors. He was also responsible for the electric lighting, heating and general engineering equipment of the shell-filling factory and the amatol factory at Aintree, near Liverpool. For his services he was awarded the O.B.E. Mr. Miller was for many years a member of the Liverpool Engineering Society, was awarded its Derby Gold Medal in 1900, and served as President in 1902-03. He was elected an associate member of the Institution

of Civil Engineers in 1885 and was made a member in 1899. He became a member of the Institution of Mechanical Engineers in 1887 and an associate of the Institution of Electrical Engineers in 1891. He was transferred to the class of member of the Institution of Electrical Engineers in 1893, and in 1906 served as chairman of the Manchester Section of the Institution.

MR. E. O. FORSTER BROWN.

WE note with regret the death of Mr. Edward Otto Forster Brown, which occurred in London after a short illness on May 22. Mr. Forster Brown, who was well known as a consulting mining engineer, having had wide experience in coalfields and iron-ore mines in this country, the British Empire and foreign lands, was born in 1881. He received his education at Aysgarth School, Yorkshire, and at Winchester, and subsequently received his training in coal mining and colliery engineering in South Wales, Northumberland, Scotland and Germany, gaining a Colliery Manager's Certificate in 1905. Mr. Forster Brown then spent two years investigating mining conditions in North America, South Africa and the Far East, and was afterwards resident consulting engineer for seven coal-mining companies in Northern Mexico. He retained this position for four years. In 1912, he returned home and started a consulting mining-engineering practice in London. He was intimately connected, either as consultant or as adviser, with the development of the Kent coalfield, various iron-ore mines in France and North Africa, and with certain anthracite mines in South Wales. He also investigated and reported on collieries and mines in Germany, Poland, Spain and elsewhere.

Mr. Forster Brown was for many years a member of the North of England Institute of Mining and Mechanical Engineers and of the Institution of Mining Engineers. As a member of the Council of the latter body he gave evidence before the Samuel Coal Commission in 1926. In September, 1939, he was elected President of the Institution of Mining Engineers and would normally have held office until September, 1941. Mr. Forster Brown was elected a member of the Institution of Civil Engineers in 1924 and was awarded a Telford Gold Medal for his paper, "Incidence of Underground Water in Kent Mining Developments," presented before the Institution in 1922. In 1935 he was appointed a member of the Royal Commission on Safety in Coal Mines. Mr. Forster Brown was a past Governor of the Imperial College of Science and Technology, and a past member of the Board of the Geological Survey of Great Britain. At the time of his death he was chairman of the Kent District Mining Board and chairman and managing director of Messrs. Chislet Colliery, Limited, Sturry, Kent. He was also a director of Messrs. Harton Coal Company, Limited, South Shields; Messrs. John Bowes and Partners, Limited, Newcastle-upon-Tyne; and Messrs. Eglinton Magnesite Brick Company, Limited. He was, moreover, consulting mining engineer to Messrs. Baldwins, Limited; Messrs. Guest Keen Baldwins Iron and Steel Company, Limited; and Messrs. International Nickel Company, Limited.

MR. H. J. ECK.

IT is with regret that we announce the death of Mr. Henry Justus Eck, which occurred after a short illness at his home in Bedford Park, London. Mr. Eck, who was a pioneer in the development of electrical illumination, was born in 1865 and educated at King's College School and at University College, London. Subsequently he went up to Peterhouse College, Cambridge, where he became an honours graduate in science and received the M.A. degree. He was then articled to Messrs. Edison Telephone Company and later to Messrs. Paterson and Cooper. He was also among the pioneers of electric traction, having designed and operated, for the Electric Motor Syndicate, an enclosed-conduit train for the Wimbledon Rifle Meeting of 1882. Later, he opened a consulting practice, and designed electrical plant for lighting the Town Hall at Oxford and the Blackwall Tunnel, and designed and supervised the construction of the Leeds Corporation Tramway undertaking. He was also responsible for many early electric light and power installations in Italy, and other European countries, as well as in many parts of the British Empire. Moreover, some of the first ammeters and voltmeters constructed for commercial use were, we believe, made by him under the direction of Professors Ayrton and Perry. Mr. Eck also produced early types of dynamos and lighting-current transformers for use on the Metropolitan Railway. He was consultant to Messrs. Edward Lloyd, Limited; Union Electric Company; Kandem Electrical Limited; and other firms, and was the author of a number of publications on arc lamps, industrial illumination and similar subjects. Mr. Eck was elected an associate of the Institution of Electrical Engineers in 1885 and was transferred to the class of member in 1891. He was one of the founders of the Electrical Industries Benevolent Association, and was for many years a member of the Council of the Illuminating Engineering Society.

MR. JOSEPH CASH.

THE death of Mr. Joseph Cash, which occurred on May 24 at his home at Hove, Sussex, removes a veteran from the ranks of the gas engineers of this country. Mr. Cash was born on December 18, 1846, and was thus in his 95th year. His long association with the Brighton and Hove Gas Company, which continued throughout his working life, commenced in 1862, when he became an articled pupil to Mr. J. B. Paddon, the engineer to the company. After the completion of his four years' pupilage, he remained with Mr. Paddon as assistant in his private practice for a further period of four years, and, in 1870, was appointed to the official position of assistant engineer to the Brighton and Hove Gas Company. In December, 1885, he succeeded Mr. Paddon as engineer to the company on Mr. Paddon's retirement and continued to occupy this position for many years, until he, in his turn, went into retirement. Mr. Cash, however, continued to reside at Hove. During his long life, he naturally saw many changes. When he was a young man, working under Mr. Paddon, the manufacture of gas was transferred from the company's stations at Hove and Black Rock to new works at Portslade, this step involving a capital expenditure of some 300,000*l*. The gradual increase in the consumption of gas made further extensions necessary from time to time. In these were included a gasholder having a capacity of one million cubic feet at Black Rock and new generating plant at Portslade, capable of producing 3½ million cubic feet of gas a day. This work was carried out under his supervision towards the end of last century. A former student member of the Institution of Civil Engineers, he was elected an associate member in 1872 and transferred to the class of member in 1891.

LETTER TO THE EDITOR.

CALCULATION OF TERMINAL SPEEDS.

TO THE EDITOR OF ENGINEERING.

SIR,—We have read Mr. Dennison's letter in your issue of April 11, page 294, and were duly impressed with the thought and ingenuity which he had evidently given to this question. In your issue of May 2, page 355, we have observed that Mr. Johansen shares this view. At the same time, we feel that the attack to which our method has been subjected is not altogether justifiable. Everyone must to some extent choose the method of working which he prefers. However, in spite of Mr. Dennison's strictures, we see no reason to be ashamed of our offspring. In fact, engineers who wish to find the free falling speed of a sphere under any given conditions are far more likely, in our view, to employ our method than Mr. Dennison's. Our reasons for making this statement are set out in detail below.

The problem, as Dennison correctly states, is the solution of a pair of simultaneous equations.

One equation is

$$\psi = f(\mathrm{R}).$$

The other can be written either as

$$\mathrm{R} = \sqrt{\frac{4}{3} \cdot \frac{n\,g\,d^3\,\rho\,(\sigma - \rho)}{\eta^2\,\psi}}$$

or

$$\mathrm{R} = \frac{3}{4} \cdot \frac{v^2\,\rho^2\,\psi}{n\,g\,\eta\,(\sigma - \rho)}$$

according to whether v or d is the required unknown.

These equations can be solved in a variety of ways:—(*a*) *Successive Approximation.*—A value of ψ or R is first guessed and then the equations are solved alternately until a constant result is obtained. This method is not quite general, since it is possible to find pairs of equations which make the successive solutions form a diverging series. (*b*) *Graphically.*—The two curves $\psi = f(\mathrm{R})$ and $\mathrm{R} = \mathrm{F}(\psi)$ are plotted and the intersection gives the solution. This method is perfectly general and is a convenient method for these particular equations since the curve $\psi = f(\mathrm{R})$ can be plotted once for all and if logarithmic scales are used the curve for $\mathrm{R} = \mathrm{F}(\psi)$ is a straight line of known slope so only one point need be calculated.

This is in effect Dennison's method. In either (*a*) or (*b*) when R is found the value of v or d follows from the relation $v = \frac{\mathrm{R}\,\eta}{d\,\rho}$ and $d = \frac{\mathrm{R}\,\eta}{v\,\rho}$.

(*c*) The equation can be rewritten

$$\psi\,\mathrm{R}^2 = \frac{4}{3}\,n\,g\,\frac{d^3\,\rho}{\eta^2}\,(\sigma - \rho)$$

or

$$\frac{\psi}{\mathrm{R}} = \frac{4}{3}\,n\,g\,\eta\,\frac{\sigma - \rho}{v^2\,\rho^2}.$$

Solutions can then be found direct without drawing lines or successive approximations with the help of curves or tables giving $\psi\,\mathrm{R}^2$ or $\frac{\psi}{\mathrm{R}}$ as functions of R. The method proposed, referred to as the B.C.S. method, is a variant of this. It is not a successive approximation method since a solution limited only by the accuracy with which the function is known and plotted is obtained by means of a definite number of operations. It is not a graphical method, since no plotting is required, only the reading of the co-ordinates of a single point on a curve which is drawn once for all.

The modification introduced is to write

$$v_s = \frac{n\,g\,d^2\,(\sigma - \rho)}{18\,\eta}$$

or

$$d_s = \sqrt{\frac{18\,\eta\,v}{n\,g\,(\sigma - \rho)}}.$$

Then

$$\psi\,\mathrm{R}^2 = 24\,\frac{v_s\,d\,\rho}{\eta} = 24\,\mathrm{R}_s$$

or

$$\frac{\psi}{\mathrm{R}} = 24\,\frac{\eta^2}{v^2\,d_s^2\,\rho^2} = \frac{24}{\mathrm{R}_s^2}.$$

R_s has a slightly different meaning according to whether the unknown is v or d.

Also

$$\frac{v}{v_s} = \frac{\mathrm{R}}{\mathrm{R}_s} = \frac{24}{\psi\,\mathrm{R}}$$

and

$$\frac{d_s}{d} = \sqrt{\frac{24}{\psi\,\mathrm{R}}}.$$

Two curves are accordingly plotted giving $\frac{24}{\psi\,\mathrm{R}}$ in terms of $\log \frac{\psi\,\mathrm{R}^2}{24}$ and $\sqrt{\frac{24}{\psi\,\mathrm{R}}}$ in terms of $\log \sqrt{24\,\frac{\mathrm{R}}{\psi}}$.

v_s or d_s and R_s are found by operations very similar to finding x_0 and y_0 in Dennison's method.

Compare the number of operations in the two methods, as shown in the table on the opposite page.

The Dennison method thus involves twice as many operations as the B.C.S. method, the additional operations being of a tedious nature and conducive to inaccuracy. If operation (8) be omitted, the diagram would rapidly become unusable.

The minimum possible number of operations is three; they are:—(1) Find $\psi\,\mathrm{R}^2 = \frac{4}{3}\,n\,g\,\frac{d^3\,\rho}{\eta^2}\,(\sigma - \rho)$.

UNIV. OF MICH.

(To face page 437.)

TRAVELLING-PIPE CONVEYOR.

MESSRS. THE OSBORN MANUFACTURING COMPANY (JOHNS CONVEYOR DIVISION), CLEVELAND, OHIO, U.S.A.

(*For Description see page* 437.)

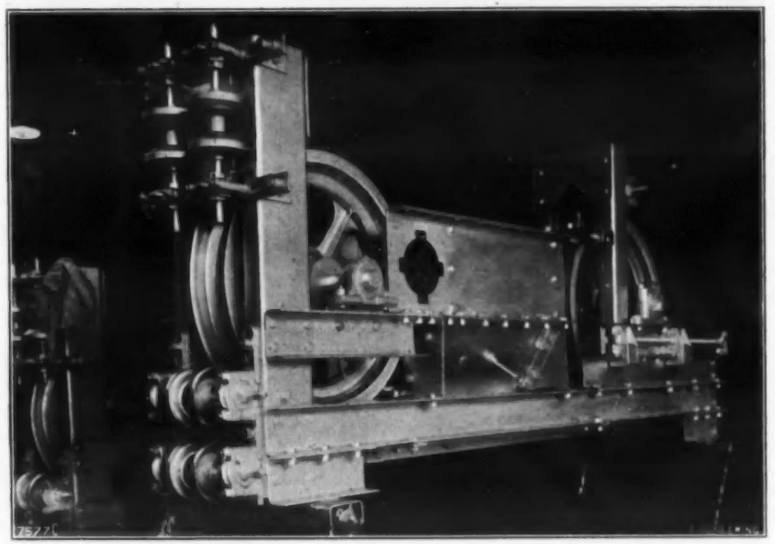


FIG. 3. LOADING POINT ASSEMBLY.

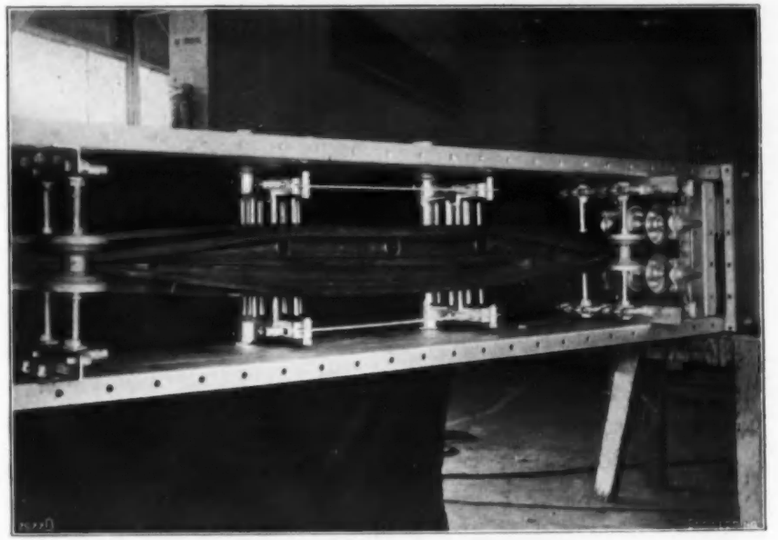


FIG. 4. INTERMEDIATE DISCHARGE POINT.

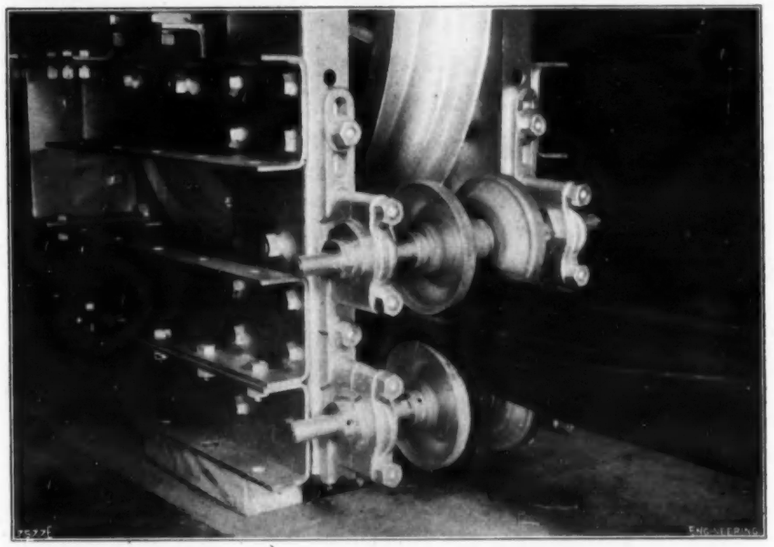


FIG. 5. CLOSING PULLEYS ON LOADING POINT.

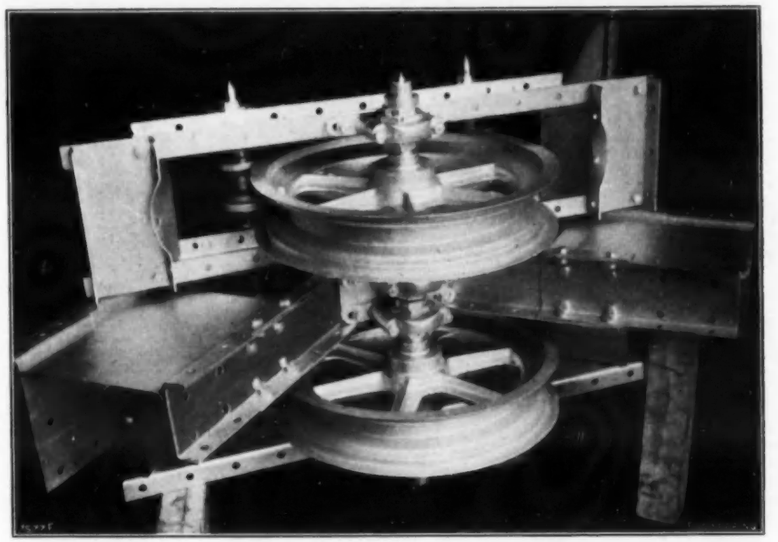


FIG. 6. FINAL DISCHARGE POINT.

(2) Find R from a curve giving R as a function of ψR^3. (3) Multiply R by $\frac{\eta}{d\rho}$.

If d is required instead of v the sequence of operations is similar. The B.C.S. method differs from this in dividing the first step into two shorter ones, the total amount of work is about the same. The great advantage of the B.C.S. method is that if R_g is less than about 1,000 the correction factor $\frac{v}{v_g}$ varies over a sufficiently narrow range to make possible the use of a linear scale instead of a logarithmic scale for the correction factor without sacrifice of accuracy or the use of a very large

Dennison.	B.C.S.
(1) Find $x_g = \log\left(\frac{d\rho}{\eta}\right)$.	(1) Find $v_g = \frac{ng d^2(\sigma-\rho)}{18\eta}$
(2) Find $y_g = \log\left\{\frac{4}{3} ng\left(\frac{\sigma-\rho}{\rho}\right) d\right\}$.	(2) Find $\log R_g = \log\left(\frac{v_g d\rho}{\eta}\right)$.
(3) Plot x_g, y_g (or x_g+1, y_g-2)	(3) Read off $\frac{v}{v_g}$ from the curve.
(4) Draw a line parallel to another line (or plot $x_g + m$, $y_g - 2m$ and join the points).	
(5) Measure a length from a point to an intersection.	
(6) Transfer this measurement to a subsidiary scale and read off log v.	
(7) Find v from log v.	(4) Multiply v_g by $\frac{v}{v_g}$.
(8) Rub out the line.	

diagram. In the region where Stokes' Law holds the correction factor is unity, and if R_g is small a glance at the curve is sufficient to show that $v = v_g$.

The method was specifically designed for use in the region of particle diameters up to about 10 times those for which Stokes' Law is applicable. For large spheres an exactly similar method based on Newton's Law is more convenient. Dennison's method is least accurate for small particles, for the intersection, ill-conditioned at all times, is most acute in this region. In order to approach the B.C.S. method in accuracy the Dennison diagram would have to be many times larger, since the variables must be plotted over a large range of values and the location of the intersection involves an additional source of error.

Yours faithfully,

C. H. BOSANQUET,
W. F. CAREY,
C. J. STAIRMAND,

Chief Engineer's Department,
I.C.I. (Fertilizer and Synthetic Products), Limited,
Billingham, Co. Durham.
May 6, 1941.

TRAVELLING-PIPE CONVEYOR.

SINCE we published an article bearing the above title in ENGINEERING, vol. 143, page 690 (1937), the travelling-pipe conveyor has been more widely adopted and improved in detail. The conveyor, which consists of an endless rubber pipe split longitudinally and opened and closed automatically to receive and discharge the material transported, is made by the Johns Conveyor Division of Messrs. the Osborn Manufacturing Company, 5,401, Hamilton-avenue, Cleveland, Ohio, U.S.A. Some idea of its appearance and the mechanism employed can be gained from Figs. 1 to 8, on this page, page 430 and Plate XXXIV. It may be as well, however, to review shortly the principles underlying the conveyor, as its title may not be self-explanatory to those not familiar with the original article. The pipe, in one sense, functions in exactly the same way as does an ordinary belt conveyor, in that solids are transferred by it from the loading point to the terminal point, and can be discharged at any intermediate point when the need arises. This, however, is the only resemblance between the two conveyors. The open belt can only transport material in a horizontal plane, or at the best at a small inclination to the horizontal, and the material, if light and powdery, may be blown away in transit. For vertical transport a bucket elevator is necessary, and this, if the route to be taken involves both vertical and horizontal movement, necessitates transference from elevator to conveyor, or vice versa, with consequent risk of loss by spilling.

On the other hand, the travelling-pipe conveyor, being as flexible and uniform as a rope, can be led, with appropriate pulley lay-outs, in any direction at will, making even right-angle turns, the material conveyed remaining through all these movements completely enclosed and so free from either loss or contamination. Further, the conveyance of the material is positive. A high-speed belt conveyor suffers from troubles due to the inertia and momentum of the material; hence the adoption of the so-called "flight" conveyor. The travelling-pipe conveyor is divided transversely at short intervals by discs, which cut off each section between the discs completely. The material trapped between the discs cannot, therefore, move relatively to the conveyor, while, on a high vertical lift, packing of the material at the lower end of the conveyor, due to the pressure of a long column of it, cannot occur. Two objections to the system may be urged, one that there must be a difficulty in keeping the halves of the conveyor in sufficiently close contact to prevent leakage and the other that, since the conveyor is made of rubber, trouble will arise from stretching under load. The halves of the conveyor are coupled by a pair of dovetails at each side, which provide an effective lock, a tight seal being ensured by the fact that the conveyor is twisted, like a rope-strand, throughout its length. The question of strength is met by embedding two chains, one in each half, in the rubber

Fig. 7.

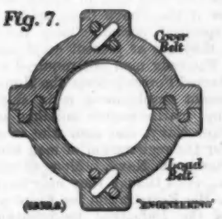
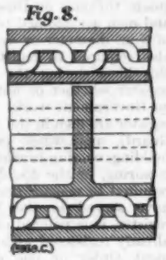


Fig. 8.



of the conveyor. The dovetails and chains are clearly shown in Fig. 7 and the chains and one of the discs in Fig. 8. The chains take the whole of the driving stresses and as now fitted are stronger and heavier than those originally used. They are made of a special heat-treated alloy and are tested for stretch before being embedded in the rubber.

At this point, it may be appropriate to refer to the manufacture of the conveyor tube, which is of circular cross-section with four diametrally-opposed ridges. The body of the tube is now made of a synthetic rubber, which is of a more inert character than natural rubber; that is, it is not affected by oil or other substances inimical to natural rubber, while it also resists the attack of many chemical elements, including a number of acids. Its abrasion-resisting properties are good and it will not stain or discolour material in contact with it. The tubing is made by Messrs. The Ohio Rubber Company, Willoughby, Ohio, U.S.A., in the press illustrated in Figs. 1 and 2, page 430. At the time the photographs, from which these views were reproduced, were taken, only one half of the press, which is a double one, had been equipped, but its construction is nevertheless quite clear, and, in some respects, notable. Thus, instead of the more conventional method of using a large casting for the entablature, a number of very deep steel joists, tied together transversely, are employed and connected to the base by ten columns arranged in pairs on the centre lines of the five rams. These rams are 18 in. in diameter, and give a total load on the platens of 1,134 tons. The press is 15 ft. square in plan and 19 ft. 4 in. high, the tube moulds being 15 ft. long, though the platens are naturally longer as will be evident from Fig. 1.

The tube is cured in 15-ft. lengths continuously, not, of course, as a complete tube, but in separate halves. The view, Fig. 2, shows the form of the moulds, of which there are two. Those on the bottom platen form the exterior contour and those on the top platen the interior contour and the dovetail ridges. The transverse discs on one half of the tube are formed by interruptions in the circular part of one of the moulds. As the chain is embedded in the rubber it is clear that it must be held in place during moulding and curing. This is effected automatically, a stress of 1,500 lb. being applied to keep it taut. The whole of the controls of the platen temperatures, length of curing time, and so forth, are automatic. The bore of the conveyor tube is not invariable, several sizes being available to suit different requirements. Typical bores are 2 in., 3 in. and 4 in., but much larger ones are available. As regards length, the limit does not appear to have been yet reached, and, in view of the varied distances and change of direction usually involved, it is not practicable to give examples. It may be stated that two typical installations, for the conveyance of nickel ore, have approximately 2,000 ft. and 1,500 ft. of tube, respectively. Similarly, as the materials handled vary so greatly in density, moisture content and other physical characteristics, no definite figures for conveying capacity are practicable. If, however, the material is assumed to weigh 100 lb. per cubic foot, a 2-in. conveyor will deliver 6 tons per hour at a conveyor speed of 100 ft. per minute, and 300 tons at the more usual speed of 500 ft. per minute. A 4-in. conveyor has, naturally, four times these capacities at the same speeds.

Some comments may now be made on the construction of the conveyor mechanism, reference being made to Figs. 3 to 6, Plate XXXIV. It will be clear that the framework is largely made up of pressed standard units bolted together. Formerly, ordinary angle framing was used, but the new construction shown in the figures is made from a metal known as "Dyn-el" steel, which is claimed to be 25 per cent. stronger than ordinary mild steel, and, what is perhaps more important, to be considerably more resistant to corrosion. The assembly shown in Fig. 3 is for a loading point, that in Fig. 4 an intermediate discharge point, while Fig. 5 is a detail of Fig. 3 and Fig. 6 shows a final discharge point. In all cases the various pulleys run in dust-sealed ball bearings with pressure lubrication throughout, so that both the starting torque and power consumption are kept low. In between the pulleys the tube is given a rope-like twist, which is partly evident in Fig. 5. The function of the small pulleys is to close the halves of the tube by pressing the dovetails one into the other; or, in some of the fittings, in passing which there may be a tendency for the joint to open, to keep them closed. Referring to the loading point, Fig. 3, the complete empty tube enters between the upper pair of small pulleys, after leaving which it is separated by passing one half round the large pulley to the left, the other half continuing round the large pulley to the right. The lower strand of this half, which, in the figure, moves from right to left, lies with the groove uppermost, and it is into this groove that the material is fed. Both halves leave the fitting at the left hand, the small pulleys at the bottom locking them together, so that the complete tube, now loaded, passes on to the discharge point.

The intermediate discharge-point is seen in Fig. 4, lying on its side, but it shows the conveyor as viewed from below. The tube is automatically opened, as shown, by passing it over two rollers, which exert pressure on the top, the material falling out. When necessary, these rollers are arranged to vibrate in order to ensure more rapid and complete discharge. Sometimes they are made retractable so that the intermediate discharge can be cut out if only occasionally required. The intermediate discs are clearly visible in one of the strands in this figure. Fig. 5 shows the leaving point of a loading fitting, at which point the empty half of the tube is pressed into the full half. It is just possible to detect the exact point of junction of the two below the left-hand bearing of the upper small pulleys. At the final discharge point, shown in Fig. 6, the tube is opened by dividing it laterally, that is, by passing each half over side-by-side pulleys, the view not showing the pulleys in their actual working position, which is with the shaft horizontal. As regards intermediate points, there is no difficulty in making a right-angle turn, two large pulleys being mounted in the same plane round which pulleys the outgoing and return strands of the complete endless tube pass. Two small pulleys are fitted at each large pulley at the bend to keep the tube closed as it passes the corner.

The travelling-pipe conveyor is readily kept clean. If necessary, air jets or water sprays can be employed at the discharge points; normally, however, such fittings are not required. When materials such as food products are to be handled, periodical washing, sterilising and drying can be effected by running the half tubes through appropriate tanks and ovens. When there is no danger of contamination, the conveyor can be used to transport different materials. A case in point is at an installation in Canada, where coal is picked up from railway wagons, lifted 60 ft., and then transported horizontally for 200 ft. to storage bunkers. The return strand of the conveyor picks up ashes and delivers them to railway wagons, discharging them in time to receive its fresh load of coal. As the tube is of soft rubber, fragile materials can be handled without risk of damage, and the conveyor can successfully handle such materials as wet mixtures, which cannot be pumped and which are too sticky to deal with in any other way. From this, it is clear that the conveyor will serve also as a pump. Materials at higher temperatures than 150 deg. F. can be transported without injury to the tube. The conveyor has also an advantage in situations where dust cannot be tolerated, since the material during conveyance is sealed in the tube.

LABOUR NOTES.

ACCORDING to the Ministry of Labour and National Service, the number of men and boys registered as wholly unemployed at April 21 was 157,239—a decrease of 15,421 compared with the position at March 17. Those registered as on short time, or otherwise temporarily suspended from work on the understanding that they were shortly to return to their former employment, numbered 41,795; this was an increase of 119. Those registered as unemployed casual workers numbered 15,515—a decrease of 1,485. The figures for women and girls at April 21 were 161,533 wholly unemployed, of whom 3,797 had been classified by interviewing panels as unsuitable for normal full-time employment. Of the total number of unemployed men nearly 37,000 were classified as not suitable for ordinary industrial employment, though perhaps equal to light work. Very few of the able men who register nowadays, it is stated, are unemployed for longer than it takes to pass from one job to another, if they are not, in fact, classified with the temporarily stopped. In the official view, there are scarcely any employable men without employment, though there may be short intervals between one job and another in which men are entitled to unemployment benefit. Of the unemployed women, approximately 33 per cent. had been on the register for less than four weeks, 42 per cent. for between four weeks and six months, 9 per cent. for between six months and twelve months, and 16 per cent. for more than a year. The figures of unemployed boys and girls were swollen by the registration of the Easter school-leavers.

Between March 17 and April 21, the numbers unemployed decreased by 4,541 in the London area, 6,060 in the Eastern area, 2,540 in the Southern area, 1,284 in the South-Western area, 641 in the Midlands area, 6,882 in the North Midlands area, 5,256 in the North-Eastern area, 3,856 in the North-Western area, 5,191 in the Northern area, 4,825 in Scotland, and 6,331 in Wales.

Replying to a question in the House of Commons last week, Mr. Tomlinson, Parliamentary Secretary to the Ministry of Labour and National Service, said that, allowing for those who were unfit for ordinary industrial employment, those temporarily out of work and about to resume it, and those changing over from one employment to another, there was now practically no reserve of unemployed labour available for, but unable to obtain, employment. All workers who were suitable for employment and who were available to be moved away from home, could be placed in employment without delay. Under any system, it was added, there must always be a relatively small number of persons who, on any particular day, are out of work between jobs.

The Ministry of Labour and National Service states that at May 1, the official cost of living index figure was 100 points above the level of July, 1914, compared with 98 points at April 1. For food alone the index figure at May 1 was 71 points above the level of July, 1914, compared with 70 points at April 1, the rise being due to increases in the price of fish. Among items other than food there was a further increase in the price of clothing and clothing materials, partly due to the purchase tax. Since that tax came into operation on October 21, the resulting increases in prices are estimated to have raised the cost-of-living index figure by nearly 4½ points.

On Wednesday and Thursday last week representatives of the Mining Association and representatives of the Mineworkers' Federation discussed in London the Federation's claim on behalf of mineworkers for a minimum wage of 4*l*. a week. Agreement was reached eventually. The desired minimum was not conceded by the coalowners, but under the scheme adopted all wages are to be increased. In the first pay-week next month there will be a flat rate addition of 1*s*. a shift to the earnings of adult miners and of 6*d*. a shift to those of juniors. The price of coal will, at the same time, be increased by 10*d*. a ton.

Mr. Lee, the secretary of the Mining Association, explained on Thursday night that the wages increase took the form of an "attendance bonus." The conditions attached to it were, he said, being embodied in a document which would be circulated to the industry at once. The bonus would be paid only to men who attended on every day on which work was available to them. If they did not turn up on one day they would lose the extra pay for the whole week. Exception would be made in the case of men who had met with an accident while at work. "It is hoped," Mr. Lee added, "that this provision will help to reduce absenteeism, and that the agreement will do something to stimulate the production of coal which the Government desires."

The text of a draft Order enabling the Central Council of Colliery Owners to make a levy not exceeding 6*d*. a ton on the saleable coal raised was given in a White Paper issued on Thursday by the Mines Department. The object of the levy is to meet the cost of the guaranteed pay week required by the Essential Work Order for the coal-mining industry.

It is stated that the trade union side of the National Joint Industrial Council for the electricity-supply industry has applied for a further advance of wages. An early meeting to consider the claim is hoped for.

The Minister of Labour and National Service has made an Order for the registration of all men with experience of marine-engine building or repairing or heavy engineering work of a similar character. To every man required to register, Mr. Bevin makes an appeal to signify, when he registers, his willingness to transfer to marine engineering if called upon to do so. Employers are asked to make every effort to release men. Each case will be considered on its merits and employers, it is stated, should not assume that men who register will at once be transferred.

The men who are to register under the Order are those aged 20 years or over who have worked for 12 months or more since January 1, 1929, on marine engine building or repairing as fitters, assemblers and erectors, or as turners. Fitters, assemblers and erectors who have been accustomed to work on steam engines, steam turbines or Diesel engines of 500 h.p. or over, and men accustomed to turning shafts or similar parts of 6 in. diameter or over and over 6 ft. in length, are also required to register if they have done work of this kind during the specified period. They must register whether or not they are at present employed on Government work. The only men not required to register are men in the Armed Forces (except the Home Guard), men whose present employment is in shipbuilding or ship-repairing, marine-engine building or repairing, or the Merchant Navy, and men who were required to register under the registration of men who have served in the Merchant Navy. Men should register, it is pointed out, even though they may have already registered under the Registration for Employment Order or one of the Industrial Registration Orders.

A national charter drafted by the Fire Brigades Union, seeks to obtain from the Government (1) An undertaking that only highly-trained, full-time men shall be in charge of fire-fighting organisations. (2) A standard rate of pay bringing A.F.S. men into line with regular firemen. (3) A general levelling up of conditions. (4) A guarantee that the Fire Brigade Union shall have full opportunity to make representations on conditions of service as a result of re-organisation. (5) The establishment of Appeals Committees to deal with hardship cases when men are ordered to transfer from one area to another. (6) The setting up of national standards for hours of duty. The union has a membership of over 60,000.

Mr. Ernest Brown, the Minister of Health, stated in the House of Commons on Thursday last week that legislation is shortly to be introduced increasing by 3*s*. the sickness and disablement benefits under National Health Insurance and raising to 420*l*. as from January next the income limit for the compulsory health and pensions insurance of non-manual workers. The weekly contributions in respect of men and women under the scheme are to be increased by 2*d*., half of which will be paid by employers and half by insured persons.

Mr. George Bell, the general secretary of the organisation, states, in the annual report of the General Federation of Trade Unions, that in 1940 the Federation lent to the Government 10,000*l*. free of interest for the period of the war; and invested 1,000*l*. in 3-per cent. Defence Bonds and 10,000*l*. in 2½-per cent. National War Bonds, 1945-47. At the end of the year, moreover, it was in process of investing 20,000*l*. in sums of 5,000*l*., from current account in 3 per cent. Savings Bonds. Half of the 20,000*l*. had been invested when the preparation of the annual report was completed.

At the end of 1940, 94 societies were affiliated to the General Federation—58 on the higher scale, 34 on the lower scale, and two on both scales. Of the membership of the affiliated societies, 190,542 were on the higher scale, 103,379 on the lower scale, and 7,804 on both scales. The membership on which contributions were based was 301,725, and the gross membership 354,132. During 1940, 25,025*l*. 11*s*. 4*d*. was received in contributions, and 149*l*. 3*s*. 4*d*. paid out in benefits.

CONDENSING PLANT AND COOLING WATER SYSTEMS.*

By W. T. BOTTOMLEY, A.R.T.C.

(*Continued from page* 420.)

Section II.—The following formula is adopted as a basis for condenser calculation:—

$$\theta_m = \frac{W\,R}{S} \quad . \quad . \quad . \quad . \quad (6)$$

where θ_m = the logarithmic mean temperature difference from the steam on outside of the tubes to the water inside in deg. F.; W = total heat transmitted per hour in thousand B.Th.U.; R = overall thermal resistance multiplied by one thousand $= \frac{1,000}{K}$; S = total internal surface of the tubes across which the heat is transmitted, in sq. ft.; K = coefficient of heat transfer in B.Th.U. per hour per sq. ft. per deg. F. temperature difference. Throughout this paper the reference to the condenser surface denotes the internal surface of the tubes.

The load on the condenser or the heat transmitted per hour (W) is given in units of 1,000 B.Th.U. W represents the equivalent pounds of steam entering the condenser per hour, assuming the latent heat is 1,000. Actually, the latent heat in the steam is less than 1,000, so that W is rather less than the actual steam entering the condenser. In modern practice, the maximum wetness fraction at the exhaust is limited to 12 or 13 per cent., in which case the minimum latent heat entering the condenser is limited to about 920 B.Th.U. per lb.

With progressive feed heating, measurement of the condensate leaving the condenser does not, as a rule, give the quantity of steam entering the condenser because it includes the drains from the feed heaters. (In spite of this the B.E.A.M.A. still insert a clause in condenser specification whereby the quantity of circulating water is determined from the temperature rise by measuring the condensate and assuming the latent heat is 950.) The load on the condenser should be determined both on test and in actual operation by the method given in the Standard Test Code issued by the B.S.I. (No. 752-1940). The load is determined by deducting from the overall consumption of the turbine the energy delivered to the shaft in heat units. The difference represents the heat extracted by the condenser. The energy delivered to the shaft is:

$$\frac{\text{H.P.} \times 2,540}{\text{mechanical efficiency}} \quad \text{B.Th.U. per hour.}$$

The mechanical efficiency for turbines over 10,000 h.p., say, is 98 to 99 per cent. Where the turbine is driving an alternator, the heat energy delivered to the shaft is:

$$\frac{\text{kW} \times 3,412}{\text{mechanical efficiency} \times \text{alternator efficiency}}$$

B.Th.U. per hour, the alternator efficiency being about 97 per cent. This method is applicable to both progressive feed heating and re-heating cycles as well as to straight non-reheating and non-feed heating cycles. The load for which the condenser should be designed should be the expected average annual load during the hours when the turbine is running. This should be the load corresponding to the rated economical load on the turbine, but generally it is about 90 per cent. of the economical rating.

The overall thermal resistance is the sum of the resistances of the various parts of the passage of heat from the steam outside the tubes to the water inside. These are the resistance of the film between the steam and the outside surface of the tubes, the resistance to conduction through the metal of the tube, the resistance to conduction through the deposit on the inside surface of the tube and the resistance of the water film inside the tube. The condenser should be designed for the average annual thermal resistance anticipated in practice and not for test conditions.

The thermal resistance of the water film from the inside of the tubes is dependent on the water velocity. The rest of the overall thermal resistance is independent of the water velocity. To determine the economical velocity of the water through the tubes it is desirable that the effect of water velocity on the thermal resistance should be expressed with a certain degree of accuracy. Data for this have been determined experimentally by Eagle and Ferguson and given in their paper in 1930† where it is shown that, for a given temperature, $R'v = f(vd)$, where R' is the thermal resistance from tube to the water. *Fig.* 5 in their paper shows $10R'v$ plotted as a function of vd when the

* Paper entitled "The Economics of the Design of Condensing Plant and Cooling-Water Systems as Applicable to Power Stations," read before the North-East Coast Institution of Engineers and Shipbuilders, at Newcastle-on-Tyne, on March 28, 1941. Abridged.

† *Proc.I.Mech.E.*, page 985 (1930).

water temperature is 60 deg. F., and Table IV in the same paper gives particulars for determining the relation for other temperatures. The range of vd for condenser design is from 2 to 7, assuming that only ½ in. and 1 in. tubes are considered, and that the range of velocities is from 3 ft. to 8 ft. per second; within this range, R_v can be represented in terms of vd by a straight line without causing a greater error in the resultant vacuum temperature than 0·05 deg. F. under economical conditions of loading. The results of Eagle and Ferguson's experiments are shown in Fig. 8, herewith, for different water temperatures, where R_v is plotted against vd. By drawing average straight lines for each temperature, the expression for R is

$$R' = \frac{R_1}{v} + R_2 d \quad . \quad . \quad (7)$$

where R_1 and R_2 are constants depending on the temperature. The values of these constants are given in Table III.

TABLE III.

Temperature. Deg. F.	R_1.	R_2.
40	4·67	0·2
60	3·88	0·183
80	3·34	0·168
100	3·0	0·15

The accuracy of this method of expressing $R'v$ may be judged from the fact that, if the loading on the condenser is 5 lb. per sq. ft. and the water velocity is 5 ft. per second, an error in $R'v$ from 3·5 to 4·5 represents an error in the vacuum temperature of 1 deg. F. The overall thermal resistance of the condenser is therefore given by:

$$R = \frac{R_1}{v} + R_o \quad . \quad . \quad . \quad (8)$$

The value of the part of the overall thermal resistance which is independent of the velocity R_o will be judged from test results for clean condensers and from operating results for the average operating condition of dirtiness; but before fixing values for these it is necessary to define the logarithmic mean temperature difference in Eq. (6) and to determine the expression for it in such a form as to enable the differentials in Eq. (3), page 418, *ante*, to be determined. The author prefers to use distinctive symbols for temperature differences. These are: x = temperature rise of water through the condenser; y = vacuum temperature fall through the condenser due to pressure drop; A = difference between initial vacuum temperature and circulating-water-inlet temperature; and B = difference between initial vacuum temperature and the circulating-water outlet temperature. Therefore

$$A = B + x \quad . \quad . \quad . \quad (9)$$

The final temperature difference = B and the initial temperature difference is $(A - y)$. Owing to the high thermal resistance of the air-cooler portion of the condenser, if there is any air or gas present in the steam, no simple formula for mean temperature difference can be devised to include the air cooler with any accuracy. We therefore adopt a conventional expression for the mean temperature difference and adjust it for the overall thermal resistance to fit the data available. In a good modern condenser the vacuum-temperature drop y is small; in some cases it is a rise, due to the recovery of velocity head. It is, therefore, proposed to use the simple Grashof formula for the logarithmic mean temperature difference based on the two temperature differences A and B, *i.e.*:—

$$\frac{\theta_m}{x} = \frac{A - B}{\log_e \frac{A}{B}} = \frac{x}{\log_e \frac{A}{B}} \quad . \quad . \quad (10)$$

The form of this equation with the logarithmic term is unsuitable for determining in conjunction with Eq. (6) the differentials of T in Eqs. (3*a*) and (3*b*), but a way out of the difficulty will be found if $\frac{\theta_m}{x}$ is plotted against $\frac{B}{x}$ as shown in Fig. 9, herewith. In the same figure is plotted also the straight line obtained if θ_m is assumed to be the arithmetical mean, the formula being:—

$$\frac{\theta_m}{x} = \frac{1}{2} + \frac{B}{x} \quad . \quad . \quad . \quad (11)$$

The extreme range of $\frac{B}{x}$ for condenser operation is from 0·4 to 1·5 and the logarithmic curve within this range can be very accurately given by a straight line, the formula being:—

$$\left.\begin{aligned} &\frac{\theta_m}{x} = a + \frac{m\,B}{x} \\ &\text{where} \quad a = 0{\cdot}4 \text{ and } m = 1{\cdot}04. \\ &\text{Therefore} \\ &\theta_m = a\,x + m\,B \\ &\qquad = m\,A - (m - a)\,x \end{aligned}\right\} \quad . \quad (12)$$

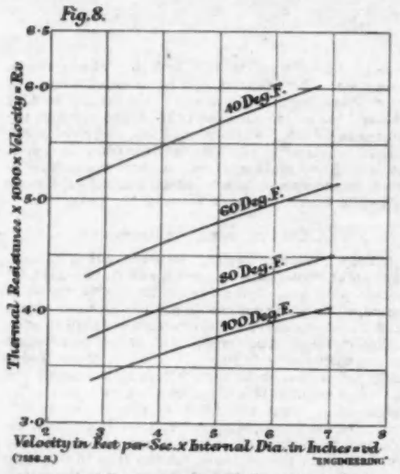


Fig. 8.
Thermal Resistance x 1000 = Velocity x Rv
40 Deg. F.
60 Deg. F.
80 Deg. F.
100 Deg. F.
Velocity in Feet per Sec. x Internal Dia. in Inches = vd
(7156.8.)
"ENGINEERING"

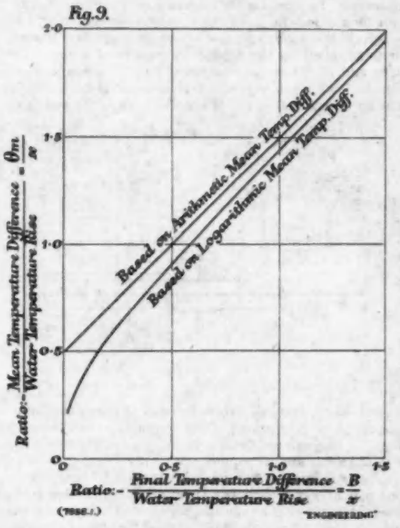


Fig. 9.
Mean Temperature Difference = θm
Water Temperature Rise x
Based on Arithmetic Mean Temp. Diff.
Based on Logarithmic Mean Temp. Diff.
Ratio:- Final Temperature Difference / Water Temperature Rise = B/x
(7156.1.)
"ENGINEERING"

Substituting the value of θ_m given in Eq. (6) and putting $A = T - t$ and $x = \frac{W}{0{\cdot}6\,G}$, the following relation is obtained for the vacuum temperature:—

$$\left.\begin{aligned} T &= \frac{W\,R}{S\,m} + \left(\frac{m - a}{m}\right)\frac{W}{0{\cdot}6\,G} + t \\ &= \frac{W\,R}{S\,m} + 0{\cdot}615\,x + t \end{aligned}\right\} \quad (13)$$

The average annual value of t, which is the circulating-water inlet temperature, is fixed for a given locality when river water is used, but for cooling towers t depends on the size of the towers.

From Eq. (13) the following differentials for Eq. (3) are obtained:

$$\frac{\delta T}{\delta S} = -\frac{R}{m}\cdot\frac{W}{S^2} \quad . \quad . \quad (14)$$

$$\frac{\delta T}{\delta G} = -\left(\frac{m - a}{m}\right)\frac{W}{0{\cdot}6\,G^2} \quad (15)$$

The first differential is independent of the quantity of water and the second is independent of the condenser surface. It is assumed for the first differential that R is independent of the quantity of water and the surface. R depends on the velocity through the tubes, and, as it will be shown later, the economical velocity is independent of the surface and the quantity of water. Eq. (13) has been found to be reliable and accurate within the range stated. It can always be checked by means of Eqs. (6) and (10). Several deductions can be made from it. For example, for constant water velocity the effect on the vacuum temperature of increasing or reducing the surface is independent of the quantity of circulating water, and the effect of altering the quantity of water at constant velocity on the vacuum temperature is independent of the surface area. Again, at constant velocity the increase in the vacuum temperature due to an increase dx is 61·5 per cent. dx.

Eq. (13) also enables the effect of variations in the value of R_o in Eq. (8) to be determined for a given condenser in operation. The variation in the value of R_o in practice is due to the effect of dirt in the tubes, but it can be due to the effect of air blanketing, and also due to pressure drop on the steam side of the condenser. For a given condenser in operation, since the velocity of the water through the tubes is proportional to the quantity of water flowing, Eq. (13) shows that the final temperature difference B does not vary more than a fraction of a degree for large variations in the quantity of water. For, since

$$T - t = A = B + x = B + \frac{W}{0{\cdot}6\,G},$$

then, by Eq. (13),

$$B = \frac{W}{S}\cdot\frac{R}{m} - \frac{a}{m}\frac{W}{0{\cdot}6\,G} \quad . \quad . \quad (16)$$

The velocity of the water through the tubes is given by Eq. (5). Eliminating G by Eqs. (5) and (16), and putting R in terms of R_1 and R_o and the velocity by means of Eq. (8), then:

$$B = \frac{W}{S}\frac{R_o}{m} - \frac{1}{v}\frac{W}{S\,m}\left\{a\frac{p^l}{d}\Big|_{4{\cdot}68} - R_1\right\} \quad . \quad (17)$$

If the value of $\frac{p^l}{d}$ is about 45, the velocity term in Eq. (17) is nil; therefore

$$B = \frac{W}{S}\cdot\frac{R_o}{m} \quad . \quad . \quad (18)$$

If $\frac{p^l}{d}$ is greater or less than 45 the correction for the velocity term in Eq. (17) will be a fraction of a degree on the value of B and the effect of changes in the water quantity and velocity can be neglected. To show the value of R_o obtained in practice, Table IV, herewith, gives twelve average monthly readings taken from the routine log sheets at Dunston "B" power station, from which the average value of R_o is determined for each month and the average obtained for the year ending June, 1940. There are four machines and the condenser of one of the machines is gun-cleaned every week-end if possible. The average value of R_o for the year is 2·3. From evidence obtained elsewhere this value for R_o appears to be normal. During the official test after gun-cleaning on one of

TABLE IV.—AVERAGE MONTHLY PERFORMANCE OF THE CONDENSING PLANTS OF DUNSTON "B" POWER STATION, SHOWING THE AVERAGE ANNUAL VALUE OF R_o IN EQUATION (8).

	Water Temperatures.			Vac. Temp. Circ. Water Inlet.	Vac. Temp. Circ. Water Outlet.	Plant Load Factor.	R_o. in Eq. (8).
	Inlet.	Outlet.	Rise.				
	Deg. F.	Deg. F.	Deg. F.	Deg. F.	Deg. F.	Per cent.	
1939.							
July	62·4	75·0	12·6	21·0	8·4	67·34	1·75
August	63·6	77·2	13·6	25·5	11·9	63·12	2·56
September	61·9	73·5	11·6	22·6	11·0	56·51	2·58
October	52·0	66·0	14·0	23·7	9·7	64·21	2·07
November	47·0	63·0	16·0	25·7	9·7	65·26	1·99
December	45·0	59·2	14·2	26·8	12·16	67·41	2·25
1940.							
January	41·0	57·0	16·0	33·0	17·0	74·45	2·94
February	40·0	57·0	17·0	32·7	15·7	77·45	2·76
March	42·8	60·2	17·4	32·1	14·7	75·42	2·57
April	48·0	64·0	16·0	26·9	10·9	83·44	1·79
May	54·8	72·04	17·24	32·9	15·3	86·64	2·32
June	65·0	80·6	15·6	27·4	11·8	79·27	2·04
							2·3 (Mean)

the condensers at Dunston, the final temperature difference B obtained was 8·3 deg. F. at 100 per cent. load, making $R_o = 1·30$. During the official test on another condenser after being wire brushed, the final temperature difference obtained was 4·5 deg. F. at 80 per cent. load and R_o was 1·00.

The power expended in pumping the water through the condenser depends on the quantity and the resistance head. The head depends on the cube of the velocity and the ratio of the quantity of water to the surface area of the condenser.

The resistance head

$$= \frac{v^3}{15}\frac{S}{G} \text{ ft.} \quad . \quad . \quad . \quad (19)$$

and the power in kW.

$$= \left(\frac{v}{36}\right)^3 S. \quad . \quad . \quad . \quad (20)$$

The resistance head depends on the dirtiness of the condenser and for economic consideration, apart from test conditions, the resistance under average annual state of dirtiness should be taken to determine the average annual pumping loss. Particulars given in Table VI of Guy and Winstanley's paper indicate that the value of the constant when wire-brushed is about 18 and, just before cleaning, is reduced to 12. For average conditions the value is assumed to be 15, and the corresponding value of the constant in Eq. (20) is assumed to be 36. From Eq. (20) the following differential for Eq. (3a) is obtained, assuming the velocity is constant:

$$\frac{\delta P}{\delta S} = \left(\frac{v}{36}\right)^3 . \quad . \quad . \quad (21)$$

The economical surface in Eq. (4a) is given in terms of a fixed water velocity because the value of R depends on the water velocity and a velocity term appears in $Z's$. The economical velocity is determined by differentiating the product $Z's$ R with respect to the velocity and equating to zero, and the economical velocity is given by the solution of the following equation:

$$\left(\frac{v}{36}\right)^3\left[\frac{3\,R_o\,v}{R_1} + 2\right] = \frac{Z_s}{Z_p}. \quad . \quad (22)$$

The result was shown in Fig. 1, on page 418, *ante*. The ratio of $\frac{Z_p}{Z_s}$ is of the order of 55 and the corresponding economical velocity is low, *i.e.*, about 4·3 ft. per second.

(To be continued.)

CATALOGUES.

Gaskets.—Messrs. J. Payen, Limited, Church-street, Chiswick, London, W.4, have sent us a supplementary price list of gaskets, for attachment to their Gasket Guide.

Motor Starters.—Messrs. Fred. W. Davies and Son, Longroyd Bridge, Huddersfield, have sent us a leaflet giving particulars of their oil-immersed star-delta starter.

Lubricants.—Messrs. Slip Products Company, Limited, Ling House, Dominion-street, London, E.C.2, have sent us two leaflets, one dealing with penetrating oil for the removal of rust and the freeing of machine parts, and the other with cutting oils.

Fixing Devices.—We have received from Messrs. The Rawlplug Company, Limited, Rawlplug House, Cromwell-road, London, S.W.7, the latest edition of their general catalogue, which, it is mentioned, may be the last that they will issue during the war period.

Cleaning Water Mains.—We have received from Messrs. Glenfield and Kennedy, Limited, Kilmarnock, a catalogue dealing with equipment for cleaning and scraping water mains. Charts are included, giving the reduction in capacity of mains from 4 in. to 36 in. in diameter, with various thicknesses of incrustation.

Stop Valves.—Messrs. Hopkinsons, Limited, Huddersfield, have sent us their latest catalogue, No. 930, dealing with stop valves, non-return valves and isolating valves of various types, suitable for pressures up to 900 lb. per square inch. Included in the catalogue is a description of their patent electric control for the power operation of valves.

Firewatchers' Posts.—We have received from Messrs. Andamite, Limited, 52, Ebury-street, London, S.W.1, descriptive leaflets relating to firewatchers' posts and "Raidsafe" shelters, the design of which, we understand, has been approved by the Ministry of Aircraft Production. Details of protective canopies for machine tools and other plant are also given.

Plastics.—The export catalogue prepared by the moulders' section of the Plastics Export Group, 11-12, Pall Mall, London, S.W.1, a copy of which we have received, contains descriptions in four languages of the various mouldings listed. It is stated that copies of this catalogue will be distributed abroad by joint agents and sub-agents on behalf of group members, who will be supplied also with samples of the mouldings illustrated.

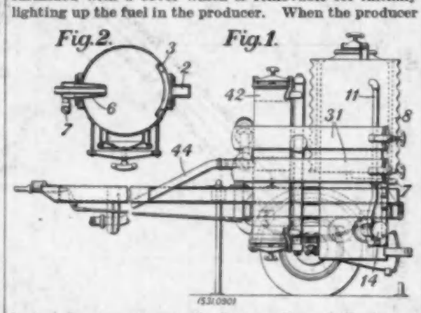
"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.
Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

FURNACE APPARATUS.

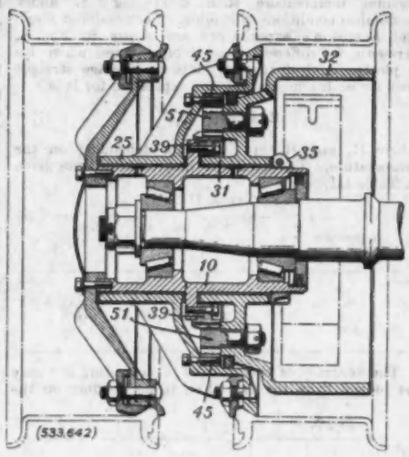
531,090. Trailer Gas Producer. R. E. Hagley, of North Harrow, T. F. Hurley, of The Fuel Research Station, Greenwich, and H. M. Lawrence, of London. (10 *Figs.*) June 27, 1939.—The invention is a cross-draught gas producer for mounting on a road trailer. The body of the producer consists of a cylindrical shell, the upper part of which serves as a fuel reservoir while the lower portion forms the combustion chamber. The gas off-take 2 (Fig. 2) leading from the combustion chamber is protected by a grid 3. The air-inlet tuyere is surrounded by a water jacket 6 connected by pipes 7 and 11 to an annular water tank 8 surrounding the body of the producer. In the tuyere jacket are vanes extending from the rear of the jacket to a point near its outlet end to permit the circulation of water through the tuyere. Air is supplied to the tuyere by means of a pipe, the lower end of which is connected with a flame box 14 furnished with a cover which is removable for initially lighting up the fuel in the producer. When the producer



is shut down, any gas evolved passes through the tuyere and flame box, and air for the combustion of this gas is supplied through an opening in the base of the flame box. The charging and ash doors are in the form of identical removable covers. The gas is delivered to the lower of one pair of cooler elements 31 on one side, passing to the other member of the pair and thence to the pair of cooler elements on the other side. From the coolers the gas passes into the filters 42, the clean gas passing out to the pipe 44. The filters have removable spacing plates and contain filter beds of, for instance, sisal tow, or oiled coke granules and sisal tow. The covers are interchangeable with the covers for the producer charging and ashing openings. It can be arranged that the throttle of the carburettor can be partly opened by the movement of the accelerator pedal when this is connected to the gas throttle in order to supply a petrol-air mixture to the engine in conjunction with the gas-air mixture, particularly when the producer is starting up. (*Accepted December* 30, 1940.)

MOTOR VEHICLES.

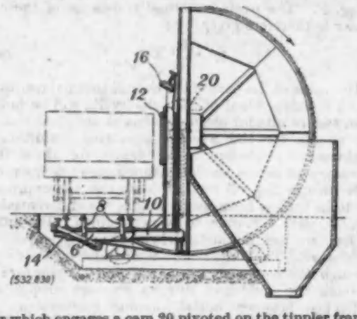
533,642. Double-Wheel Assembly. Differential Wheel Corporation, of Detroit, U.S.A. (5 *Figs.*) September 13, 1938.—The invention is an arrangement of double wheel for heavy vehicles, which incorporates a differential gear between the two wheels and a common brake drum. The assembly shown is for mounting on a trailing axle, this axle carrying a pair of roller bearings. These bearings support an elongated hub 10, on which the outboard wheel is bolted. Just within the web of the outboard wheel the hub 25 of the inboard wheel rotates on a sleeve on the hub 10, while on the inner portion of the hub 10 is journalled the hub 31 of a brake drum 32, a lock nut 35 on the inner end of the hub 10 holding the brake drum in place longitudinally. The differential gear connection between the two independently rotatable wheels and the independently rotatable brake drum consists of an external gear ring 39 bolted to the hub 10, and thus to the outboard wheel, and an internal gear ring 45, of larger diameter bolted to the inboard wheel. Four planet pinions 51 mesh with both gear rings, their axles being mounted in the flat end face of the brake drum 32. In ordinary use, the two wheels and the brake drum rotate together, and unequal rotation of the wheels, at corners or on rough surfaces, is permitted by the differential gearing, with corresponding idle rotation of the brake drum. When the brakes are applied, the normal tendency is to retard both wheels with the brake drum as a unit, but a greater braking torque is exerted on the inner wheel than on the outer wheel, due to the greater diameter of the gear ring 45, and this makes for safety



as it is thus difficult to skid both the wheels at the same time. The assembly can be arranged to take a power drive from the engine by bolting an annular sprocket ring on the inner end of the brake drum 32, the construction being slightly modified to give added strength. Where the assembly is driven from the engine, the driving and braking torques are both transmitted to the independently rotatable wheels through the same differential gear. (*Accepted February* 18, 1941.)

RAILWAYS AND TRAMWAYS.

532,838. Wagon Tippler. Strachan and Henshaw, Limited, of Bristol, and T. Sargent and G. Grossmith, of Bristol. (8 *Figs.*) September 21, 1939.—The tippler is self-adjusting to any size of wagon. The wagon-supporting table 6 is connected by links 8 to the lower limb 10 of an L-shaped frame. The vertical limb of this frame slides against the wagon side stop 12. The heel of the B rests upon one of the longitudinals of the tippler frame and the toe of the limb 10 is slung on a link 14 from another longitudinal. Thus the truck is carried on a link-supported cradle which hangs like a pendulum from the L-shaped frame, and this, in turn, hangs pendulum fashion from the main tippler frame. A top stop 16 is carried on an arm pivoted to the tippler frame. In the normal position the top stop rests against the tippler frame clear of any vehicle passing over the table. The arm carries a



roller which engages a cam 20 pivoted on the tippler frame but held in a fixed position when the latter rotates. As the roller rides over the surface of the cam 20 the top stop 16 is forced outwards to a definite position irrespective of the height of the wagon being tipped. After the tippler has been rotated through a few degrees, the table 6 is swung sideways on the links 8 so that the body of the wagon rests on the side stops 12. The top stop 16 also begins to move to its position for holding the wagon when it becomes inverted. After rotation of the tippler through 80 deg., the links 14 become vertical, so that further rotation permits the wagon, still in contact with the table, to swing gently against the top stop. Any width and height variation in the wagons is taken up by the pendulum action whereby wagons of all sizes can be automatically accommodated. The clamping operation is smooth and shockless throughout. (*Accepted January* 21, 1941.)